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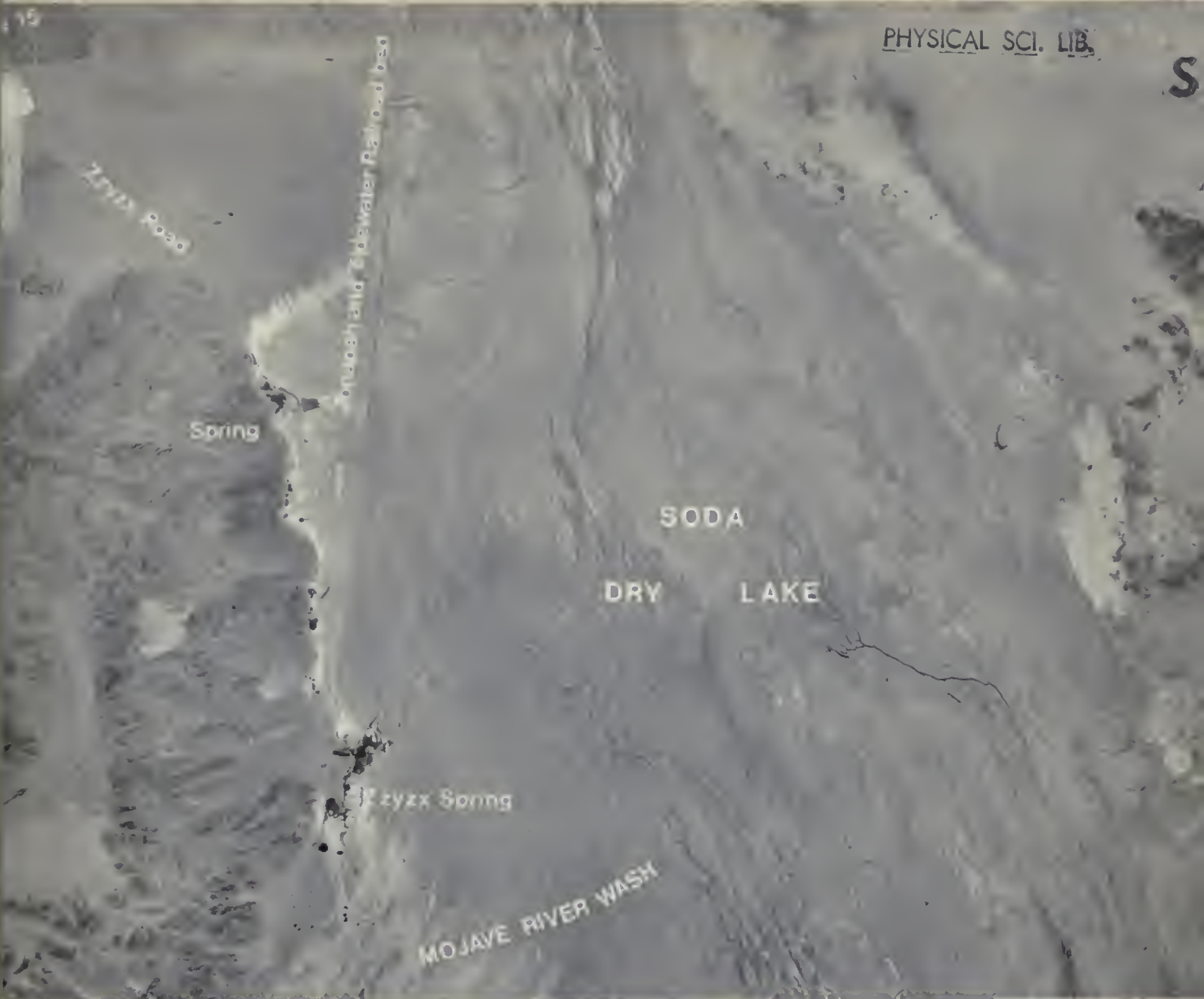

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ON THE COVER—Aerial photograph of the central part of Soda dry lake in Soda Lake Valley (6-33). Zzyzx Spring is the site of an Army fort on the Government trail in 1858, a railroad station in 1917, a health spa in 1967, and is presently used as a study area for the State school system. U.S. Geological Survey photo GS-YS, 1-43, taken July 1, 1953.

Department of
Water Resources

Bulletin 91-24

Sources of Powerplant Cooling Water in the Desert Area of Southern California—Reconnaissance Study

August 1979

Prepared by
United States Department of
Interior Geological Survey
Federal-State Cooperative
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CONVERSION FACTORS

The inch-pound system of units is used in this report. For readers who prefer metric units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
acre	0.4047	hm^2 (square hectometer)
acre-ft (acre-foot)	.001233	hm^3 (cubic hectometer)
acre-ft/yr (acre-foot per year)	.001233	hm^3/yr (cubic hectometer per year)
ft (foot)	.3048	m (meter)
ft/yr (foot per year)	.3048	m/yr (meter per year)
gal/min (gallon per minute)	.06309	L/s (liter per second)
(gal/min)/ft (gallon per minute per foot)	.2070	(L/s)/m (liter per second per meter)
inch	25.40	mm (millimeter)
mi (mile)	1.609	km (kilometer)
mi^2 (square mile)	2.590	km^2 (square kilometer)

Degree Fahrenheit (°F) is converted to degree Celsius (°C) by using the formula: $°C = (°F-32)/1.8$.

FOREWORD

BY THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

The availability of cooling water is a basic requirement for the operation of an electric power plant that uses steam to generate electricity. For this reason, the prime location for such plants has been along the coast where sea water can be used.

As the demand for electricity has increased, however, the number of new coastal sites that are available has declined, and planners are looking toward inland locations.

Where to find the water for cooling purposes within these plants then becomes of major concern. Accordingly, the California Department of Water Resources undertook an investigation of possible water sources and, in 1977, published the results of its study.

In the foreword to that publication, Bulletin 204 "Water for Power Plant Cooling," I pointed out that "the water management policy of the Department of Water Resources provides in part, '...that the water resources of California shall be managed in a manner that will result in the greatest long-term benefit to the people of the State... (and that) water shall be reused to the maximum extent feasible.' In keeping with this policy, the 'Water Quality Control Policy on the Use and Disposal of Inland Waters Used for Powerplant Cooling' of the State Water Resources Control Board, and Resolution No. 76-16 'Urging Use of Waste and Brackish Water for Power Plant Cooling Purposes' of the California Water Commission, the Department recommends that agricultural waste water, brackish ground water, or other water not suitable for municipal and agricultural purposes should be used for power plant cooling insofar as possible."

As a first step toward use of brackish ground water at inland locations, the United States Geological Survey, under a cooperative agreement with the Department, has undertaken a reconnaissance-level study of ground water basins in desert portions of California to provide and evaluate hydrologic data and identify those basins that are hydrologically suitable for steam-electric power plant sites. This report presents the results of the initial phase of that study.

Ronald B. Robie

Ronald B. Robie, Director
Department of Water Resources
The Resources Agency

SOURCES OF POWERPLANT COOLING WATER IN

THE DESERT AREA OF SOUTHERN CALIFORNIA--RECONNAISSANCE STUDY

By J. H. Koehler and A. P. Ballog, Jr.

ABSTRACT

A hydrologic reconnaissance was made of 142 ground-water basins in the desert area of southern California to determine which basins could provide sufficient cooling water for a 1,000-megawatt fossil-fueled electric-power generating plant.

The suitability of each basin was evaluated on the basis of the following criteria: Minimum recoverable storage of 1 million acre-feet; minimum well yield of 500 gallons per minute; water of sufficiently poor quality to not be in demand for domestic or agricultural uses; and lack of development in the basin.

Using these criteria, the following five basins were classified as suitable: Middle Amargosa Valley (6-20), Soda Lake Valley (6-33), Caves Canyon Valley (6-38), Chuckwalla Valley (7-5), and Calzona-Vidal Valley (7-41, 7-42).

The following six basins were classified as suitable with qualifications; these basins seem to meet the established criteria, but in some respects the available data are inconclusive: Coyote Lake Valley (6-37), Harper Valley (6-47), Panamint Valley (6-58), Rice Valley (7-4), Dale Valley (7-9), and Palo Verde Mesa (7-39).

Thirteen basins were placed in the insufficient-data category; the suitability of these basins is unknown because of insufficient data for a proper evaluation. The remaining basins were considered to be unsuitable.

Except for the basins classified as unsuitable, a more detailed evaluation in two phases is warranted. The next phase could include water-level measurements, collection of water samples for chemical analysis, and a reconnaissance gravity survey. The final stage could include a detailed gravity survey and the drilling of test wells.

INTRODUCTION

Many forecasts of electric-power needs indicate a great increase in power requirements. The California Region Framework Study Committee (1972) predicted a 20- to 25-fold increase over the 1965 power usage by the year 2020. Hydroelectric powerplants will provide only 3 percent of this need, even if their present capacity is doubled. Steam-electric plants will provide 97 percent of the power needs.

The committee assumed that most of the power requirements would be met by seashore plant sites where seawater would be used for cooling. Concerns about the marine environment, the esthetics of coastal plants, earthquake hazards, and various other environmental aspects have created a need to consider inland powerplant sites.

Thermal powerplants require small quantities of water of good quality heated to produce steam. The steam is used to run a turbine that drives a generator, thus producing electricity. Large quantities of cooling water are required to condense the steam so that it can be recycled through the system. Inland power generation will probably require between 300,000 and 400,000 acre-ft of cooling water annually by the year 1990 (California Department of Water Resources, 1974).

The California Department of Water Resources asked the U.S. Geological Survey to conduct a reconnaissance that would permit classification of desert basins on the basis of their hydrologic suitability as electric powerplant sites.

Objectives and Scope

The objectives of this study and report were to:

1. Determine hydrologic criteria with which to evaluate the ground-water basins with regard to their suitability for a powerplant site.
2. Evaluate and classify the basins, with regard to the criteria as (a) suitable, (b) suitable with qualifications, (c) insufficient data to classify, and (d) unsuitable.
3. Discuss the hydrologic characteristics of the basins considered to be suitable and suitable with qualifications.
4. Outline a program for making additional hydrologic investigations before basins classified suitable, suitable with qualifications, and insufficient data are considered for powerplant sites.

Powerplant siting is dependent on many factors in addition to hydrology. Among these are accessibility, site costs, environment, waste disposal, transmission lines, seismic conditions, and land subsidence.

This study was limited to determining the availability of an adequate supply of cooling water within the range of the determined hydrologic criteria. Included is an evaluation of data on ground water in storage, well yield, water quality, and state of development of selected basins. The environmental effects of pumping large quantities of water for cooling purposes were not addressed in this study.

Most of the data used in this report were obtained from published reports and U.S. Geological Survey data files (not referenced in text). These data were supplemented or substantiated by reconnaissance field observations.

Description of the Area

The study area (fig. 1) is bordered on the northwest and southwest, respectively, by the Sierra Nevada and by coastal mountain ranges, on the northeast and east, respectively, by the Nevada and Arizona State borders, and on the south by Mexico. Encompassed are about 47,000 mi^2 of mountains and alluvium-filled ground-water basins. The basins range in size from a few square miles to 1,870 mi^2.

The mountains are composed generally of consolidated rocks which, except where fractured, yield little or no water to wells. The basins are composed of unconsolidated alluvial sediments consisting of boulders, gravel, sand, silt, and clay. Coarser sediments generally predominate in alluvial fans near the mountains and grade to finer sediments in the central part of the basin. Where saturated, the sediments yield moderate to large quantities of water to wells.

Hydrologic characteristics vary considerably among basins and within individual basins. Water quality, especially, is variable within some basins; dissolved-solids concentrations may range from a few hundred milligrams per liter in areas of recharge to several hundred thousand milligrams per liter in the central part of the basin.

Many of the ground-water basins are connected hydrologically, therefore, recharge or discharge in an individual basin may affect the hydrologic regimen of adjoining basins.

The climate is characterized by low annual precipitation and low humidity. Average annual precipitation ranges from less than 3 inches in the lower basins to 50 inches in the higher altitudes along the northwest edge of the study area. Many of the basins are occasionally subjected to intense rain, usually of short duration, that causes flash flooding. Summer temperatures in excess of 100°F are common in the lower basins. High temperatures and frequent strong winds cause a high rate of evapotranspiration.

In general the area is sparsely populated. Urban and agricultural development have largely been confined to areas having water of good quality.

FIGURE 1.--Location of study area.

Basin Names and Numbers

The California Department of Water Resources has divided the State into nine hydrologic study areas. Two of these, the South Lahontan (fig. 2) and the Colorado Desert (fig. 3), constitute this study area. For the purpose of this study the ground-water basins in the hydrologic study areas are identified by a name and numbering system prescribed by the California Legislature (California Department of Water Resources, 1952). Each basin has been given a name, which generally is the name of a physiographic feature in the basin, and a number, which identifies the hydrologic study area and the specific basin. In the example 6-20, the 6 represents the South Lahontan hydrologic study area, and the 20 identifies the Middle Amargosa Valley Ground-Water Basin. Basins in the Colorado Desert hydrologic study area are indicated by a 7 followed by the individual basin number. Basin numbers 6-1 through 6-8 are in the North Lahontan hydrologic study area and are not included in this report.

A second numbering system is used to identify the surface drainage province in which the basin is located. The number corresponds to the hydrologic unit or subunit and represents an areal designation system devised by the Southern District office of the California Department of Water Resources to facilitate machine handling of basic data (California Department of Water Resources, 1964a). For example: W-9.DO represents the Amargosa Hydrologic Subunit within the Lahontan Drainage Province, and X-17.00 represents the Chuckwalla Hydrologic Unit within the Colorado River Basin Drainage Province.

Well-Numbering System

Wells are numbered according to their location in the rectangular system for subdivision of public land. The part of the number preceding the slash, as in 7S/21E-14A1, indicates the township (T. 7 S.); the part following the slash indicates the range (R. 21 E.); the number following the hyphen indicates the section (sec. 14); the letter following the section number indicates the 40-acre subdivision according to the lettered diagram below. The final digit is a serial number for wells in each 40-acre subdivision. A Z before the final digit indicates that the well is plotted from an unverified location description. The absence of the last letter and serial number indicates that the well has not been assigned an official well number.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

CRITERIA USED TO CLASSIFY BASINS

Before criteria for classifying basins can be established, the type and size of the proposed powerplant must be known so that an estimate can be made of the amount of cooling water required.

Water requirements for a nuclear powerplant are higher than for a fossil-fueled plant (Davis and Wood, 1974). Problems with disposal of radioactive waste from nuclear powerplants are likely to restrict the construction of nuclear powerplants in the near future. Therefore, cooling-water requirements for this study were based on the assumption that future powerplants in the study area would operate on fossil fuels.

In a powerplant site study conducted by the University of California, Los Angeles (1977), a powerplant capacity of 1,000 megawatts was used as a basis for evaluating various sites in California and Nevada. Water requirements assumed in this study were also based on a 1,000-megawatt powerplant.

The amount of cooling water required for a powerplant run on fossil fuel depends on several variables, such as plant efficiency, type of cooling system, water quality, and air temperature. Estimates of consumptive use range from 15 acre-ft/yr (U.S. Bureau of Reclamation, 1975) to 30 acre-ft/yr (University of California, Los Angeles, 1977) per megawatt of powerplant capacity. The water being considered in this study is somewhat high in dissolved solids, and the air temperatures are high; both factors increase the amount of cooling water required. Therefore, the higher estimate of 30 acre-ft/yr per megawatt was used in this study.

The hydrologic criteria used to classify ground-water basins are: (1) quantity of ground water in storage, (2) expected yield of water wells, (3) chemical quality of ground water, and (4) extent of development or established water use.

Storage

Adequate water must be available for long-term withdrawals to insure the longevity of a powerplant. Based on a plant life of 30 years, a 1,000-megawatt powerplant would consumptively use about 900,000 acre-ft of water. Therefore, only those basins with at least 1 million acre-ft of recoverable water in storage were considered potential powerplant sites.

Recoverable ground water in storage, hereafter referred to as storage, was considered to be water available to wells in the upper 500 ft of basin sediments. Storage was computed by multiplying specific yield times saturated thickness (in feet) times basin size (in acres). Specific yield was obtained from previously published data or estimated from drillers' logs by using the method described by Davis, Green, Olmsted, and Brown (1959). Saturated thickness was obtained by subtracting the average depth to water from the average thickness of alluvial sediments or 500 ft, whichever was smaller. For the purpose of this study, 500 ft was arbitrarily chosen as the maximum economical dewatering depth.

Many of the basins receive recharge from adjacent basins or from natural sources such as percolation of streamflow. Water from these sources will help to replenish the ground water taken from storage, thereby prolonging the useful life of the basin.

Well Yield

To determine well-yield criteria, several factors must be considered. Selecting a minimum well yield that is too high would virtually eliminate all but a few basins. Selecting a minimum well yield that is too low would necessitate a large number of wells, which would require a larger well-field area and more pipeline. At some point it would become cost prohibitive. Because of the above, a minimum well yield of 500 gal/min was selected. At 500 gal/min, 37 wells pumping continuously would be required to produce the 30,000 acre-ft/yr of water for a 1,000-megawatt plant. However, assuming a minimum of 500 gal/ min, it is probable that the average well yield would be greater, because well yields will vary from well site to well site.

Well-yield data are sparse for most of the basins. Data that are available most often reflect the pump capacity, casing size, and well depth and may not represent maximum well yield that could be obtained at the site. For this reason, drillers' logs were used to estimate well yields available in some basins. In many instances, properly constructed test wells would be required to obtain representative well-yield data. This could be accomplished in future phases of the investigation.

Water Quality

Cooling water that produces little or no corrosion or incrustation of the cooling apparatus is desirable. If cooling water is initially low in dissolved solids, it can be recycled through the cooling system several times before the dissolved solids become too concentrated. Therefore, water low in dissolved solids is best for powerplant cooling.

Basins containing ground water of good quality have generally been developed for agricultural or other uses. Large withdrawals for powerplant cooling would

FIGURE 2.--Northern part of study area, showing classification of basins for powerplant siting.

FIGURE 3.--Southern part of study area, showing classification of basins for powerplant siting.

create additional stresses on the hydrologic system and conflict among water users.

To avoid competing with other water users, only the basins that contain water unsuitable for most agricultural and domestic uses were considered, in this study, as potential powerplant sites. Many chemical constituents could restrict water usage; however, only dissolved solids, fluoride, arsenic, boron, and percent sodium were considered in this reconnaissance. They are the most critical, and data on these constituents are generally available. Minimum concentrations were set at 1,000 mg/L (milligrams per liter) dissolved solids, 1.5 mg/L fluoride, 50 µg/L (micrograms per liter) arsenic, 2,000 µg/L boron and percent sodium of 75. An upper limit for dissolved solids was arbitrarily set at 30,000 mg/L to avoid severely restricting the times the water could be recycled through the cooling system.

There is a considerable range in quality of water within many basins; in these cases a judgment had to be made on the basis of predominant quality and potential for uses other than powerplant cooling.

Basin Development

The criteria for basin development were established to avoid conflict among competitive uses of the land and ground water. Basins that have been extensively developed were eliminated from consideration as powerplant sites in this study.

Development in a basin generally reflects availability and quality of the water. Basins that have been extensively developed would, in many cases, also be eliminated on the basis of water quality.

Basins that are largely or totally within a national monument or military reservation were also eliminated from consideration because of established land use.

APPLICATION OF CRITERIA

Each of the 142 ground-water basins in the study area was evaluated with respect to the hydrologic criteria established for this study. Each basin was classified in one of the following categories: (1) suitable, (2) suitable with qualifications, (3) insufficient data to classify, and (4) unsuitable.

1. The basins that are rated suitable meet or exceed the established criteria for cooling-water requirements. A brief evaluation of the hydrologic characteristics of these basins is presented in this report.
2. The basins rated suitable with qualifications are those that apparently meet the established criteria but in some respect the data are not conclusive. A brief evaluation of the hydrologic characteristics of these basins is presented in this report.
3. The basins classified in the insufficient-data category are those in which the available data are inadequate to evaluate the basin with respect to the established criteria. As additional data become available, these basins could be included in one of the other categories. A table listing these basins, their size, and brief remarks is presented in this report.
4. The basins classified in the unsuitable category did not meet the established hydrologic criteria. A table listing these basins, the criteria eliminating the basin, and a brief explanation is presented in this report.

BASINS CONSIDERED SUITABLE FOR POWERPLANTS

The basins that are classified suitable meet or exceed the established criteria for cooling-water requirements. Table 1 summarizes the hydrologic characteristics of these basins and is followed by a brief description and evaluation of each basin.

Middle Amargosa Valley (6-20)

Basin description.--The Middle Amargosa Valley Ground-Water Basin (fig. 4) is in the Amargosa (W-9.D2) and Chicago (W-9.D3) Hydrologic Subunits. Total area of the basin is 1,300 mi^2, of which 620 mi^2 is in Inyo County, Calif., and 680 mi^2 is in Nevada. Only the part in California is considered in this study.

The basin is 60 mi long and has a maximum width of about 12 mi. The axis of the basin trends northwest, roughly paralleling the Amargosa River. Access to the basin is by State Highway 127 from the south and State Highway 190 from the west. The basin is bordered on the east by the Resting Spring and Nopah Ranges, on the south by the Sperry Hills, on the west by the Ibex Hills, the Greenwater Range, and the Funeral Mountains, and on the north, for the purpose of this study, the Nevada State boundary. The altitude of the basin floor ranges from 1,300 ft above sea level in the southern part to 2,300 ft near the Nevada State line. Eagle Mountain in the central part of the basin rises to an altitude of 3,800 ft.

Mean annual precipitation in the basin is 4 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 32°F and 60°F in January, 72°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--Quaternary alluvium is exposed in most of the basin. These deposits are more than 900 ft thick (California Department of Water Resources, 1964b). Alkali Flat, in the north-central part of the basin, is composed of fine-grained playa-type sediments that cover an area of 3.5 mi^2.

Water levels in the northern part of the basin ranged from 24 ft below land surface in well 27N/4E-26B1 to 3.1 ft below land surface in well 25N/5E-14M1 in 1978. Artesian conditions exist in the southern part of the basin south of Shoshone. The water level in well 21N/7E-28N1 was about 100 ft above land surface shortly after being drilled in March 1967. Water levels in the northern part of the basin have remained fairly constant. The water level in well 25N/5E-14M1 was reported to be 3.5 ft below land surface in April 1965 and 3.1 ft below land surface in April 1978. Data on water-level fluctuations in the southern part of the basin are not available. The several springs and flowing wells in the area, however, suggest that the artesian head has remained above land surface.

The ground-water contours (fig. 4) show that the movement of water is from the Nevada side of the basin southeastward toward Alkali Flat. Lack of data precludes the drawing of contours south of Alkali Flat. Some of the underflow is probably lost by evaporation of shallow ground water at Alkali Flat, and the remainder moves southeastward past Eagle Mountain.

Ground-water recharge is derived principally from underflow from the north. To a lesser extent, recharge is derived from infiltration of infrequent flow in the Amargosa River and the tributary valleys. Recharge to the artesian area in the southern part of the basin is probably derived from rainfall infiltration in the higher altitudes of the basin and the surrounding mountains.

Ground-water discharge occurs by evaporation from the surface, transpiration by vegetation, and pumping. Springs and flowing wells bring water to the surface where it is evaporated or consumed by vegetation. Phreatophytes along the Amargosa River obtain water directly from the water table. Lush vegetation near Shoshone consumes water from springs and probably directly from the aquifer. Ground-water discharge also occurs as underflow out of the basin to the south into Valjean Valley (California Department of Water Resources, 1964b).

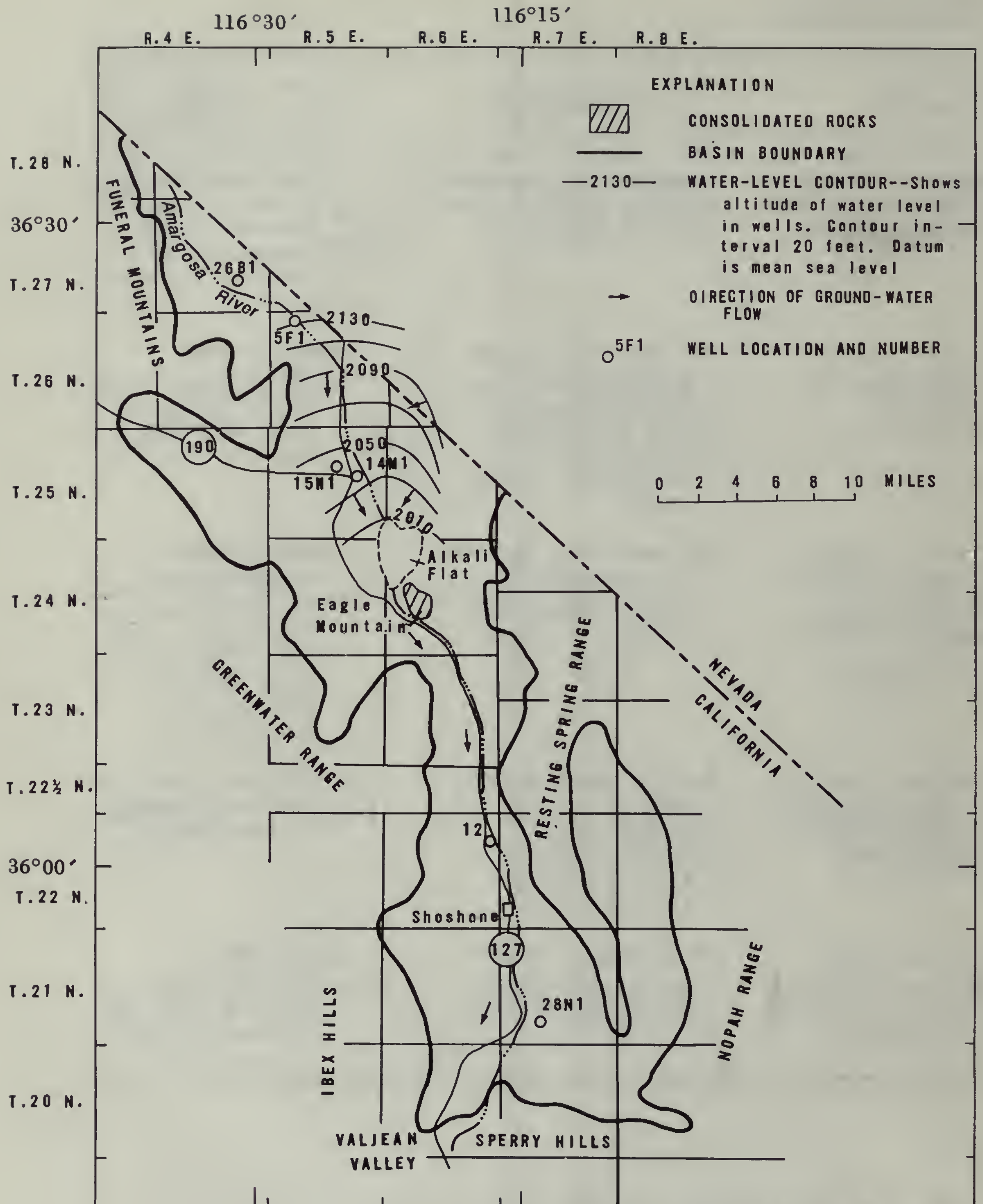
Storage.--The water level in the central part of the basin is near land surface; however, it is reasonable to assume that it is much deeper near the periphery of the basin. The average depth to water for the whole basin was assumed to be 100 ft, and a saturated thickness of 400 ft was used in calculating storage. The average specific yield for the upper 100 ft of aquifer is 17 percent (Walker and Eakin, 1963). The specific yield generally becomes less with depth due to compaction

TABLE 1.--Basins considere

Basin name and number	Basin size (mi^2)	Storage (acre-ft)	Well yield
Amargosa Valley 6-20	620 (California part)	18,000,000, assuming an average saturated thickness of 400 ft.	Up to 4,266 gal/min reported for the Nevada part of basin
Soda Lake Valley 6-33	590	4,000,000, assuming an average saturated thickness of 400 ft in an area of 150 mi^2.	Up to 1,700 gal/min.
Caves Canyon Valley 6-38	100	2,000,000; estimate reported by the Mojave Water Agency.	Up to 1,900 gal/min reported in adjacent basin. Similar yields can be expected in this basin.
Chuckwalla Valley 7-5	870	15,000,000, assuming an average saturated thickness of 300 ft.	Average 1,800 gal/min with a maximum of 3,900 gal/min.
Calzona-Vidal Valley 7-41, 7-42	310	3,500,000, assuming an average saturated thickness of 250 ft.	Up to 1,800 gal/min.

suitable for powerplants

Water quality	Basin development	Remarks
Dissolved solids range from 566 to 3,990 mg/L. Locally high in fluoride, boron, or arsenic.	Only two wells are presently being used in the northern part of the basin.	The northern part of the basin would probably be more suitable for a powerplant site than the southern part.
Dissolved solids up to about 4,000 mg/L. Locally high in fluoride and boron.	The only significant ground-water withdrawals are near the town of Baker at the north edge of the basin.	Recharge from adjoining basins would help maintain water levels.
Dissolved solids range from 261 to 1,270 mg/L. Water is generally high in percent sodium.	Not more than 10 wells are presently being used in the basin.	Basin receives recharge from adjoining basin and occasionally from surface flow in the Mojave River.
Dissolved solids range from 274 to 12,300 mg/L. Locally high in fluoride, boron, and percent sodium.	Most of the development is in the vicinity of Desert Center. Agricultural use is declining.	Hydrologic conditions vary considerably in the basin.
Dissolved solids range from 400 to 1,500 mg/L. Locally high in fluoride and percent sodium.	Development limited to the area along the Colorado River.	Basin may receive some recharge from the Colorado River.



Ground-water contours from G.E. Walker and T.E. Eakin (1963). Basin boundary approximated from California Department of Water Resources (1964b)

FIGURE 4.--Ground-water basin, Middle Amargosa Valley (6-20).

of sediment. A specific yield of 12 percent was assumed to be more representative of the upper 500 ft of sediment. Using these values the usable storage was estimated to be 18 million acre-ft.

Well yield.--Data on maximum well yield are not available for the study area; however, yields up to 4,266 gal/min were reported for wells in the Nevada part of the basin (Walker and Eakin, 1963). Properly designed wells in the study area would probably yield more than 500 gal/min.

Water quality.--There is a considerable range in water quality within the basin. Dissolved-solids concentrations ranged from 566 to 3,990 mg/L in water samples from wells 27N/4E-26B1 and 26N/5E-5F1, respectively. Water from several wells contains excessive quantities of fluoride, boron, or arsenic. For example, water from well 26N/5E-5F1 had 8 mg/L fluoride; water from well 22N/6E-12 had 17,200 μg/L boron; and water from well 25N/5E-15H1 had 11,000 μg/L arsenic.

Some of the wells and springs in the southern part of the basin produce hot water. The temperature of water from well 21N/7E-28N1 was 49°C in 1967. The temperature of water from springs is as high as 42°C.

Basin development.--The generally poor quality of the water has been largely responsible for the lack of agricultural development in the basin. The present economy is dependent primarily on providing services for tourists. Only two wells are being used in the northern part of the basin, and water requirements in the southern part of the basin are provided by springs. Because the water is of poor quality, it seems unlikely that demand for ground water will significantly increase in the near future.

Basin assessment.--The basin meets the criteria for a powerplant site. With further detailed investigation, a site might be found that would yield water high in fluoride, boron, or arsenic, and low in dissolved solids. This type of water would be most desirable because it could be recycled through the cooling system many times before becoming too high in dissolved solids.

The southern part of the basin would be less suitable than the northern part because of the hot water and artesian conditions. The hot water would have to be cooled before being used. Pumping from the artesian zone would probably lower the potentiometric head and cause the springs in the area to dry up.

The area north of Alkali Flat would probably be best suited for a powerplant site. The basin is probably deepest in this area; therefore, more water from storage would be available. Underflow from the north would help to maintain water levels but a pumping depression would probably form around the well field. Eventually, depending on the quantity pumped, the water under Alkali Flat, which may be of poor quality, might move into the pumping depression and cause a change in the quality of the water being pumped.

Soda Lake Valley (6-33)

Basin description.--Soda Lake Valley Ground-Water Basin (fig. 5) is in the Soda Lake Hydrologic Subarea (W-28.H2) of central San Bernardino County. The irregularly shaped basin has a maximum length of 45 mi and width of 26 mi, but it encompasses only about 590 mi^2.

The Union Pacific Railroad traverses the southern part of the basin in an east-west direction. Access to the basin from the north is by State Highway 127 which ends at Baker, the only town in the basin. Interstate Highway 15 roughly parallels the northwest boundary. The basin is bounded on the east by low hills composed of consolidated rocks, on the south by the Bristol Mountains and Cady Mountains, on the west by the Cady Mountains and Cronese Mountains, and on the north by Silver Lake Valley. Soda Lake, a playa at an altitude of about 925 ft, is the lowest part of the basin. The highest point in the basin is Old Dad Mountain at an altitude of 4,250 ft.

Mean annual precipitation in the basin is about 4 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 32°F and 60°F in January, 76°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).

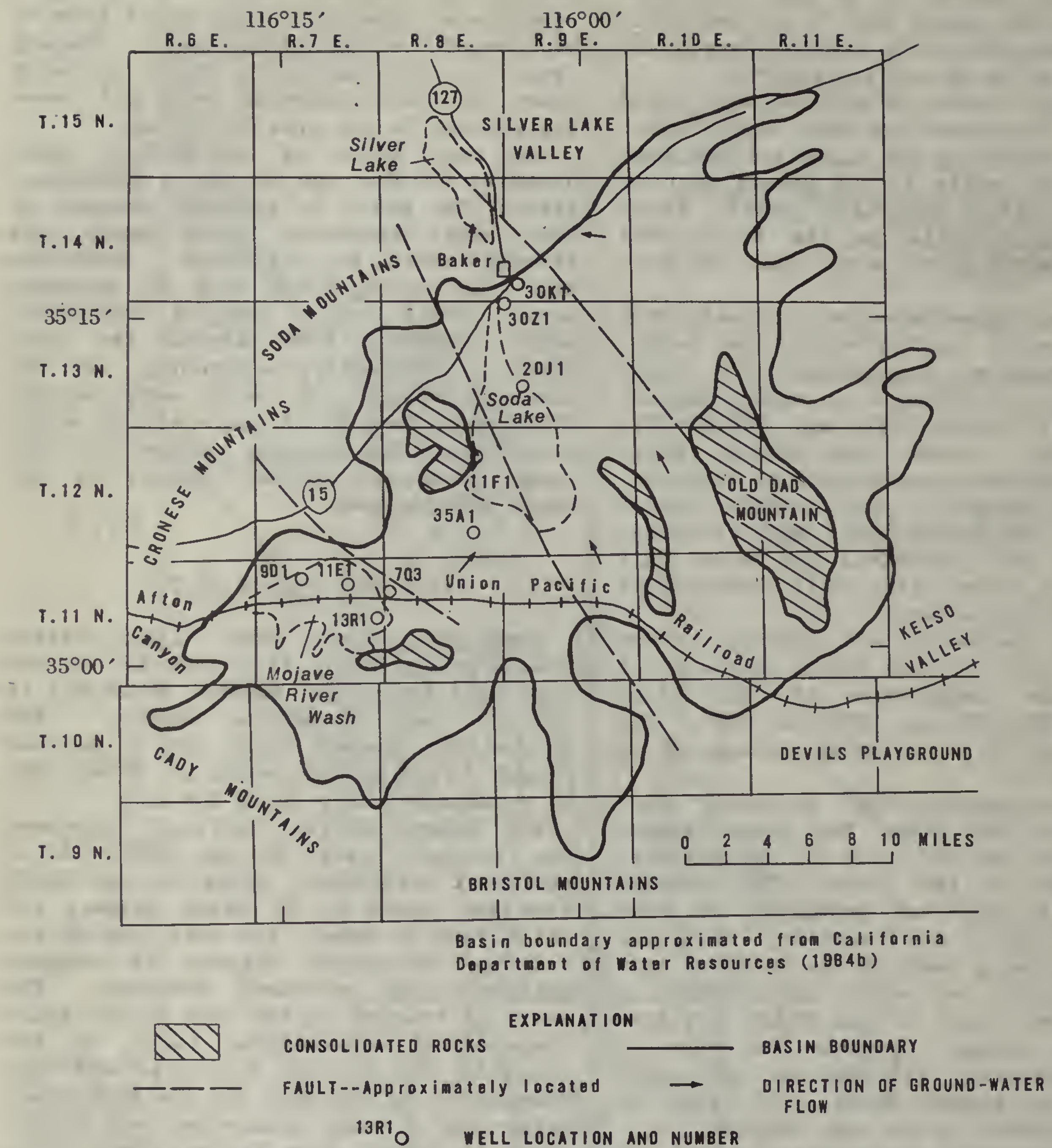


FIGURE 5.--Ground-water basin, Soda Lake Valley (6-33).

Hydrologic characteristics.--Quaternary alluvium covers most of the valley floor. The alluvial deposits are 630 ft thick at well 11N/7E-9D1; well 14N/9E-30Z1 was drilled to a depth of 502 ft and did not reach consolidated rock. Judging from surface topography, the deepest part of the basin is probably near the southern part of Soda Lake.

Depth to water in 1965 ranged from 8 ft below land surface in well 12N/8E-35A1 to 76 ft below land surface in well 14N/9E-30K1. No water-level data are available for the northeastern part of the basin, but water levels are probably much deeper owing to higher land-surface altitudes and limited recharge. The average water-level decline in 10 wells between 1954 and 1965 was 2.9 ft, an average of 0.26 ft/yr (Moyle, 1967a).

Ground water moves from the Mojave River Wash and the Devils Playground areas toward Soda Lake and then northward out of the basin. Ground-water movement may be impaired to some extent by three faults that cross the basin in a northwesterly direction (fig. 5).

Recharge is from rainfall in the basin, percolation of streamflow, and underflow from adjoining basins. Recharge from rainfall in the basin is slight because of low average annual rainfall (4 inches) and the high-evaporation rate that results from the hot climate. Streamflow in the Mojave River enters the basin through Afton Canyon. Average annual flow through Afton Canyon is 3,830 acre-ft (U.S. Geological Survey, 1976). Much of this flow percolates into the ground when it reaches the Mojave River Wash or just beyond. When flash flooding in the Mojave River occurs, the streamflow reaches Soda Lake and on occasion spills over into Silver Lake to the north. Most of the water that reaches the lakes is lost to evaporation because the lakebed sediments are impermeable.

Ground water enters the basin as underflow at Afton Canyon on the southwest and from the Devils Playground area on the southeast. Some underflow may be entering the basin from the northwest between the Cronese Mountains and Soda Mountains.

Ground-water discharge occurs by evaporation of water from springs on the west side of Soda Lake. Evaporation of ground water under Soda Lake may occur where the water is near the land surface. There is underflow northward out of the basin through the Baker area and into the Silver Lake Valley Ground-Water Basin. The only wells known to be in use are at Baker, which has a population of about 300. The water being pumped at Baker would otherwise move into the Silver Lake area.

Storage.--Storage in the basin is difficult to estimate because of lack of data. The outcropping of consolidated rocks in the hills and mountains throughout the basin indicates that the bottom of the basin is very irregular, thus, an average depth of unconsolidated sediments cannot be estimated with any degree of certainty. It may be safe to assume, however, that the saturated thickness in the central part of the basin from Afton Canyon to Baker is at least 400 ft. Assuming an area of 150 mi^2, a saturated thickness of 400 ft, and a specific yield of 10 percent, the storage is nearly 4 million acre-ft. This is probably a low estimate.

Well yield.--Yield data are available for several wells in the basin (Moyle, 1967a). They average about 200 gal/min. Most of these wells were not designed for high yield; they are relatively shallow, averaging about 130 ft, and have casing generally less than 8 inches in diameter. Wells 11N/8E-7Q3 and 13N/9E-20J1, which are presently unused, are considered representative of wells designed for high yield; their yields were 1,000 and 1,700 gal/min, respectively. Well 11N/8E-7Q3 had a reported specific capacity of 13 (gal/min)/ft of drawdown.

Water quality.--There is a considerable range in water quality in the basin (Moyle, 1967a). The dissolved-solids concentration in a water sample collected in 1919 from well 11N/7E-11E1 was 363 mg/L. This well is in the Mojave River Wash area and is probably representative of the water being recharged into the basin by surface flow. Dissolved solids in a water sample collected in 1954 from well 11N/7E-13R1, about 2 mi southeast of 11E1, were 1,120 mg/L. Well 13R1 is 142 ft deeper than 11E1 and may obtain water from a different source. Dissolved solids in a water sample collected in 1955 from well 12N/8E-11F1, on the west side of Soda Lake, were 2,010 mg/L. The sample also contained 10 mg/L of fluoride and 2,200 μg/L of boron. This water is typical of wells in the area. The quality of water from wells near Baker varies from about 900 to 4,000 mg/L dissolved solids.

In addition to high dissolved solids, high concentrations of various individual constituents make the water in most parts of the basin generally unsuitable for agricultural and domestic uses.

Basin development.--The only wells known to be in use in the basin supply the town of Baker (population about 300). Agricultural development has been attempted in the past, but it failed because of poor water quality. It is unlikely that there will be substantially larger demands for ground water in the near future.

Basin assessment.--The basin meets the criteria for a powerplant site. If substantial quantities of ground water were pumped for powerplant cooling, water levels would decline, but underflow from adjoining basins would reduce the rate of decline. Water quality in the basin varies considerably; therefore, if large quantities were pumped, the quality might change as water from outside the well field moves into the pumping depression. If the well field were in the northern part of the basin, the resulting pumping depression might cause water levels to decline in the wells serving the town of Baker.

Caves Canyon Valley (6-38)

Basin description.--Caves Canyon Valley Ground-Water Basin (fig. 6) is in the Caves Hydrologic Subarea (W-28.G1). The basin is in the central part of San Bernardino County about 25 mi northeast of Barstow on Interstate Highway 15.

The basin has an irregular shape and is about 15 mi long and 8 mi wide; it encompasses about 100 mi^2. It is bounded on the north by Alvord Mountain and the Cronese Mountains, on the east by Cave Mountain, on the southeast by the Cady Mountains, and on the west by a topographic divide that separates it from the lower Mojave River Basin. The Mojave River traverses the basin in a northeasterly direction. The altitude of the riverbed is 1,760 ft in the southwestern part of the basin and 1,400 ft at Afton Canyon.

Mean annual precipitation in the basin is about 4 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 33°F and 60°F in January, 72°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--Quaternary alluvium is exposed in most of the valley.

The water level is near the surface in the southwestern part of the basin near the Mojave River, is nearly 200 ft below land surface in well 11N/5E-16J1, and rises to the surface near Afton Canyon. The water level in well 16J1 declined about 18 ft between 1950 and 1961, an average of 1.6 ft/yr. Water-level declines elsewhere in the basin are generally less than 1 ft/yr (Dyer and others, 1963).

Ground-water movement is northeastward, roughly parallel to the Mojave River channel. Underflow rises to the surface before entering Afton Canyon; it flows through the canyon as surface water and reenters the ground on the east side of Afton Canyon in Soda Lake Valley.

Recharge is by percolation of rainfall in the drainage basin, percolation of surface flow in the Mojave River, and underflow from the southwest. Limited rainfall, warm temperatures and consequent high evaporation rate, and the small area of the basin preclude much recharge from precipitation in the basin. On rare occasions, because of flash flooding upstream, the Mojave River contains flow throughout the basin. On these occasions considerable recharge occurs from infiltration in the river channel. Average

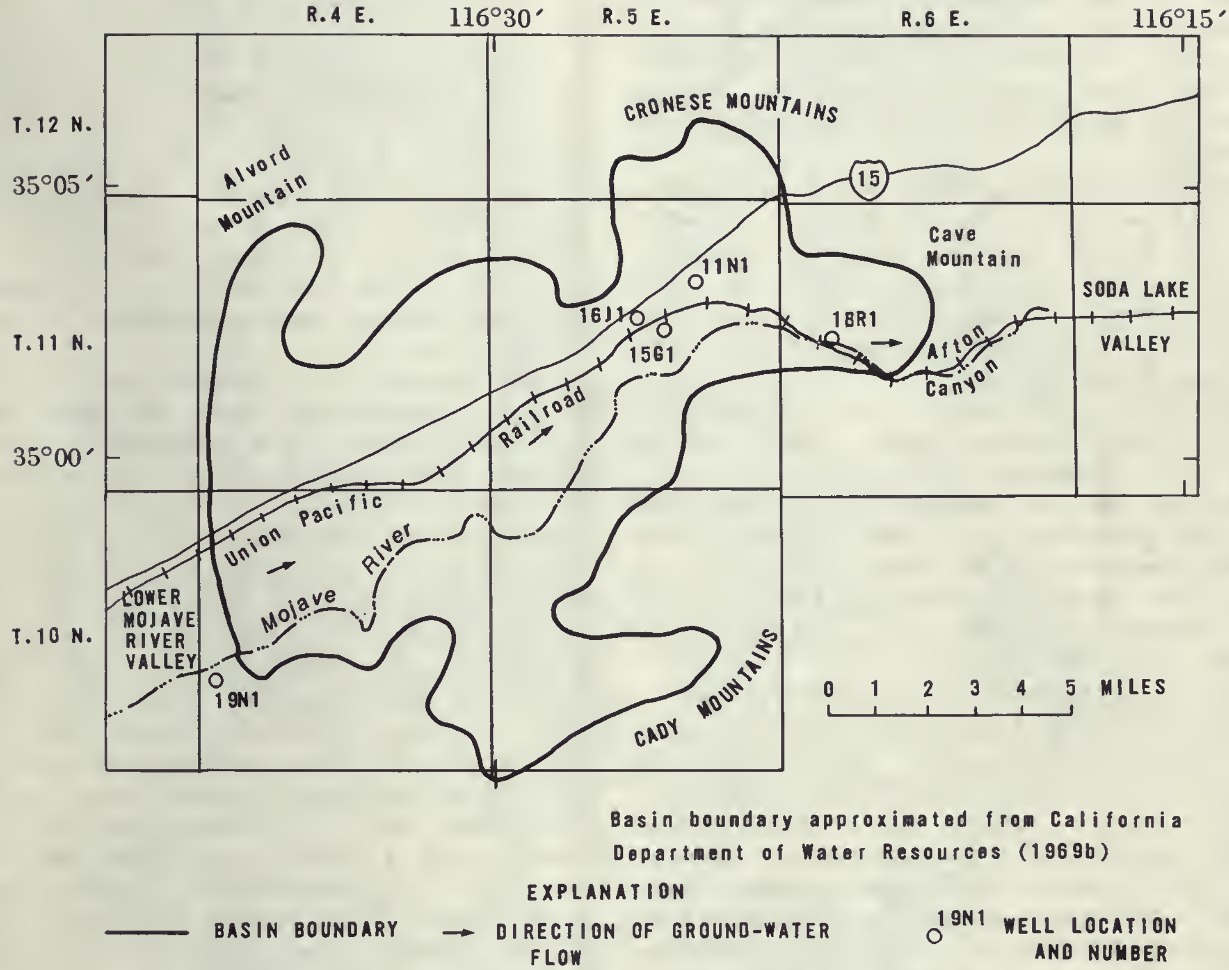


FIGURE 6.--Ground-water basin, Caves Canyon Valley (6-38).

annual underflow entering the basin from the southwest has been estimated to be 1,000 acre-ft (California Department of Water Resources, 1967).

An annual average of about 3,800 acre-ft of water leaves the basin as surface flow at Afton Canyon (U.S. Geological Survey, 1976); part of this is ground water that has risen to the surface. Most of the wells in the basin are unused; however, several wells in the southwestern part of the basin are used for domestic purposes. Probably less than 5 acre-ft of ground water is being extracted annually from the basin.

Storage.--Total ground water in storage was estimated to be 2 million acre-ft (Mojave Water Agency, written commun., 1978). This was based on a specific yield between 10 and 25 percent, an area of 57,000 acres, and a depth to water between 90 and 177 ft.

Well yield.--Few data are available on well yields in the basin. The average yield for 10 wells in T. 10 N., R. 3 E., southwest of the basin, is 990 gal/min and the maximum is 1,900 gal/min. The aquifer properties in Caves Canyon Valley basin are probably similar to those on the southwest; therefore, similar well yields could be expected.

Water quality.--The dissolved-solids concentration is relatively low, ranging from 261 mg/L in well 10N/4E-19N1 to 1,270 mg/L in well 11N/5E-11N1 (Dyer and others, 1963). Sodium and percent sodium values generally make the water unsuitable for domestic and agricultural purposes. The average sodium concentration in wells 11N/5E-11N1, 15G1, and 11N/6E-18R1 was 323 mg/L and the average percent sodium was 93.

Basin development.--The basin has not been developed and probably will not be developed, mainly because the water is of inferior quality. A few wells, probably not more than 10, are used in the southwestern part of the basin along the railroad.

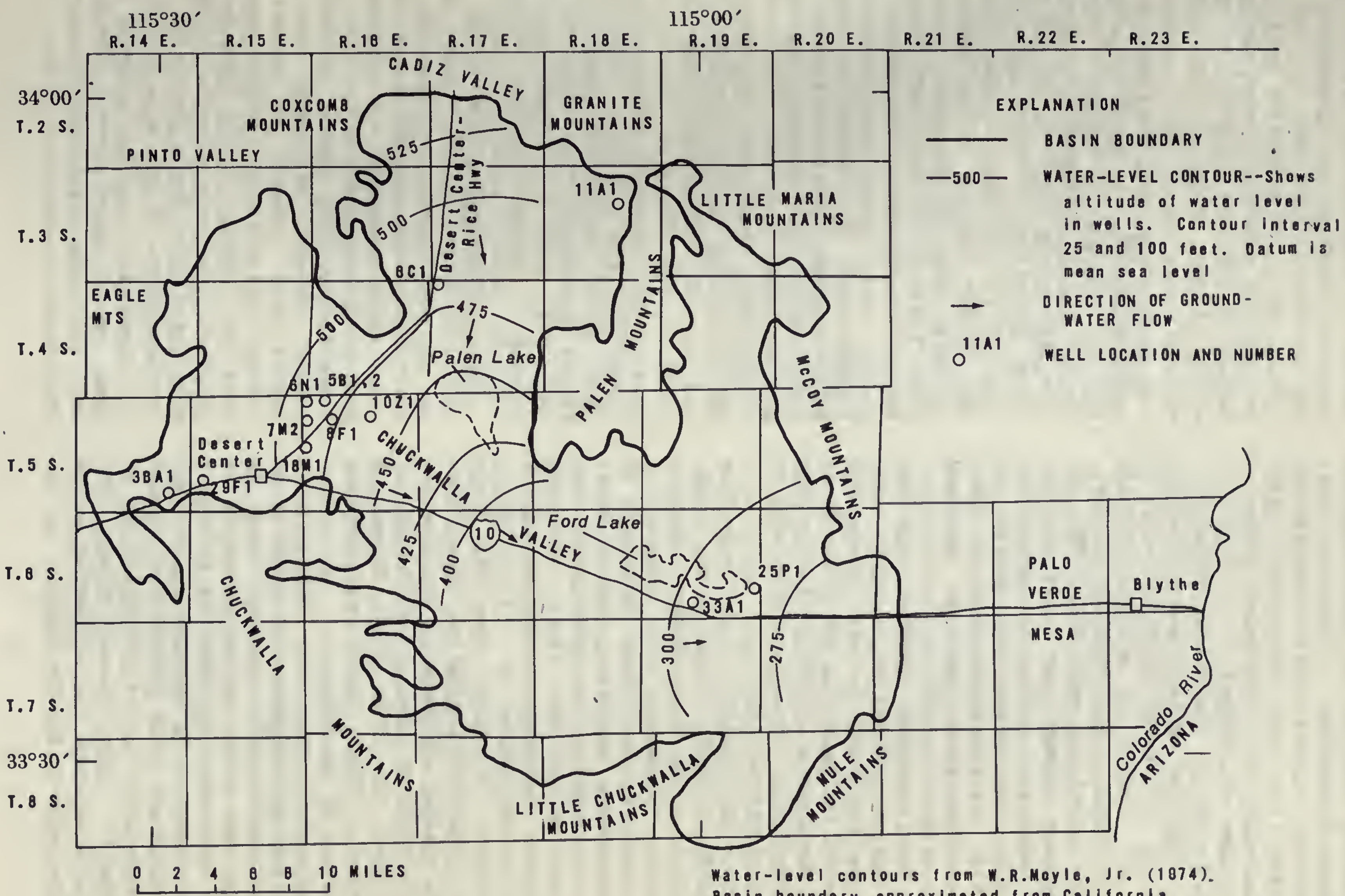
Basin assessment.--The basin meets the criteria for a powerplant site. If large quantities of water were pumped from the basin, water levels would decline in and around the well field. Recharge from underflow and infrequent flow in the Mojave River will help to reduce the decline. Pumping large quantities of water from the basin will probably reduce or even stop the flow out of the basin through Afton Canyon.

Chuckwalla Valley (7-5)

Basin description.--The Chuckwalla Valley Ground-Water Basin (fig. 7) is in the Ford (X-17.A0) and Palen (X-17.B0) Hydrologic Subunits. The basin encompasses 870 mi^2 in the eastern part of Riverside County, west of Palo Verde Mesa. It is a desert area of internal drainage with no perennial streams and two dry lakes, Ford and Palen, within its boundaries.

The basin is approximately 45 mi long and has a maximum width of about 35 mi; its axis trends in a southeasterly direction. Access to the basin is provided by Interstate Highway 10 from the east and west and by the Desert Center-Rice Highway from the north and south. The basin is bounded on the south by the Chuckwalla, Little Chuckwalla, and Mule Mountains; on the north by the Little Maria, Coxcomb, and Granite Mountains, on the west by the Eagle Mountains, and on the east by the Mule and McCoy Mountains. The Palen Mountains extend into the basin from the north. Valley floor altitudes range from 1,500 ft near the base of the mountains to 350 ft near the center of Ford Lake. The center of Palen Lake is about 400 ft above sea level. A slight topographic high between the Palen Mountains and Chuckwalla Mountains forms a surface-drainage divide separating the Ford and Palen Hydrologic Subunits.

The basin has a typical desert climate, hot and dry. Mean annual precipitation is about 4 inches (Rantz, 1969). Sporadic flash flooding occurs during periods of excessive rainfall. Mean daily minimum and maximum temperatures are 42°F and 68°F in January, 80°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).



Water-level contours from W.R.Moyle, Jr. (1974).
Basin boundary approximated from California Department of Water Resources (1964b)

FIGURE 7.--Ground-water basin, Chuckwalla Valley (7-5).

Hydrologic characteristics.--The main water-bearing material is unconsolidated sedimentary deposits. Most of this sediment was water-laid as alluvial-fan, stream-channel, and lake or playa deposits, with some sand being deposited by wind (Giessner, 1963a).

Water levels in the basin range from 485 ft below land surface in well 5S/14E-36A1, west of Desert Center, to 21 ft below land surface in well 4S/17E-6C1, north of Palen Lake (Giessner, 1963a). The water level in well 5S/16E-8F1, at Desert Center Airport, was reported to be 83.0 ft below land surface in April 1961; it was 81.05 ft below land surface in April 1978. Data indicate that the water level in the basin has not declined significantly.

Water-level contours (fig. 7) for the basin indicate that the ground water moves from the north and west toward the gap between the Mule and the McCoy Mountains. There is no evidence that ground-water movement is impeded or displaced by faults or other barriers.

Ground-water recharge is by underflow from the Pinto Valley basin on the northwest and from the Cadiz Valley basin on the north. Recharge also occurs by infiltration of runoff from the slopes of the surrounding mountains, and a small quantity of recharge may come from infrequent rain on the basin floor. Data are insufficient to compute the amount of recharge to the basin.

Ground-water discharge from the basin occurs by evapotranspiration from Palen and Ford Lakes; by pumping for domestic and agricultural uses, estimated as 9,100 acre-ft for 1966 (U.S. Bureau of Reclamation, 1972); and by underflow eastward out of the basin.

Storage.--Drillers' logs indicate a maximum aquifer thickness of 1,200 ft at well 6S/19E-33A1. The average depth to water for the basin was estimated to be 200 ft; therefore, a saturated thickness of 300 ft was used in calculating storage. A specific yield of 10 percent was assumed to be representative of the upper 500 ft of sediment. Using these values, the recoverable storage was estimated to be 15 million acre-ft for the basin.

Well yield.--Well yields for the basin average 1,800 gal/min, with a maximum yield of 3,900 gal/min from well 5S/16E-5B2 north of Desert Center. This well is 715 ft deep, has a 16-inch casing, and is pumped with a 60-horsepower turbine pump. This size and type of well are representative of the wells in the area having similar yields.

Water quality.--The Chuckwalla Ground-Water Basin has a wide range in water quality (Giessner, 1963a). Dissolved-solids concentrations range from 274 mg/L, in well 5S/15E-29F1, to 12,300 mg/L, in well 3S/18E-11A1. The water of best quality in the basin comes from wells near Desert Center in the western part. In this area the dissolved solids range from 274 mg/L to 730 mg/L. Dissolved-solids concentration increases as the ground water moves downgradient and is highest near the center of the basin. Water from well 6S/19E-33A1 had a reported dissolved-solids concentration of 2,150 mg/L in 1959.

Water from several of the wells in the basin contains levels of fluoride, boron, and percent sodium that make the water inferior for domestic and agricultural uses. For example, water from well 5S/16E-8F1 had 8.0 mg/L fluoride; water from well 6S/19E-25P1 had 3,600 µg/L boron; and water from wells 5S/16E-5B1, 6N1, 7M2, 8F1, 10Z1, and 18M1 all had percent sodium greater than 90.

Basin development.--Development of the basin has been limited because the water is of poor quality. In 1966, 1,900 acre-ft of water was used for crop irrigation, while municipal and industrial uses were 1,700 acre-ft and 5,500 acre-ft, respectively (U.S. Bureau of Reclamation, 1972). Almost all the domestic and agricultural pumpage is around Desert Center, with little or no development near the two dry lakes, Ford and Palen. The industrial use of water is by mining activity in the Eagle Mountains. From a reconnaissance of the area in April 1978, it appeared that no additional development has occurred around Desert Center and that the agricultural acreage is declining.

Basin assessment.--The basin meets the criteria for a powerplant site. The limited development in the Desert Center area is not a significant competitive use of the ground water, and the large size of the basin will permit the siting of a plant far enough away from Desert Center to minimize the effects of pumping on the existing wells. The large quantities of water that will be extracted from the basin over a period of years, however, will cause significant declines in the water levels in and around the powerplant well field. By locating the wells near the center of the basin, where the water of poorest quality is in storage, the pumping depressions will not change the direction of the ground-water gradient but may steepen the gradient toward this area, and the water quality there may gradually improve.

The water of good quality in the Desert Center area may eventually move eastward toward these pumping depressions, and water levels will decline, but the quality of the water in the Desert Center area will not be affected because recharge occurs by underflow from the west.

Calzona-Vidal Valley (7-41, 7-42)

Basin description.--The Calzona-Vidal Valley Ground-Water Basin (fig. 8) is in the Vidal Hydrologic Subunit (X-15.A0). The California Department of Water Resources (1975) separates Calzona and Vidal Valleys into two ground-water basins. For this study the two basins are considered as one because both basins are within a single hydrologic subunit and the subsurface characteristics are similar. The two valleys have previously been evaluated as one ground-water basin by the U.S. Geological Survey (Bader, 1969a).

The basin encompasses 310 mi^2 in the eastern part of San Bernardino and Riverside Counties adjacent to the Arizona border. It is drained by the Vidal Wash into the Colorado River. The basin is about 30 mi long and has a maximum width of about 18 mi. Its axis trends east-west. Access to the area is by U.S. Highway 95 and State Highway 62.

The basin is bounded on the south by the West Riverside Mountains and Riverside Mountains; on the west by the Turtle Mountains; on the north by the Mopah Range and Whipple Mountains; on the east by the Colorado River; and on the southwest by Rice Valley (7-4). The altitude of the valley floor ranges from about 1,500 ft near the base of the mountains on the west to about 400 ft at the Colorado River on the east.

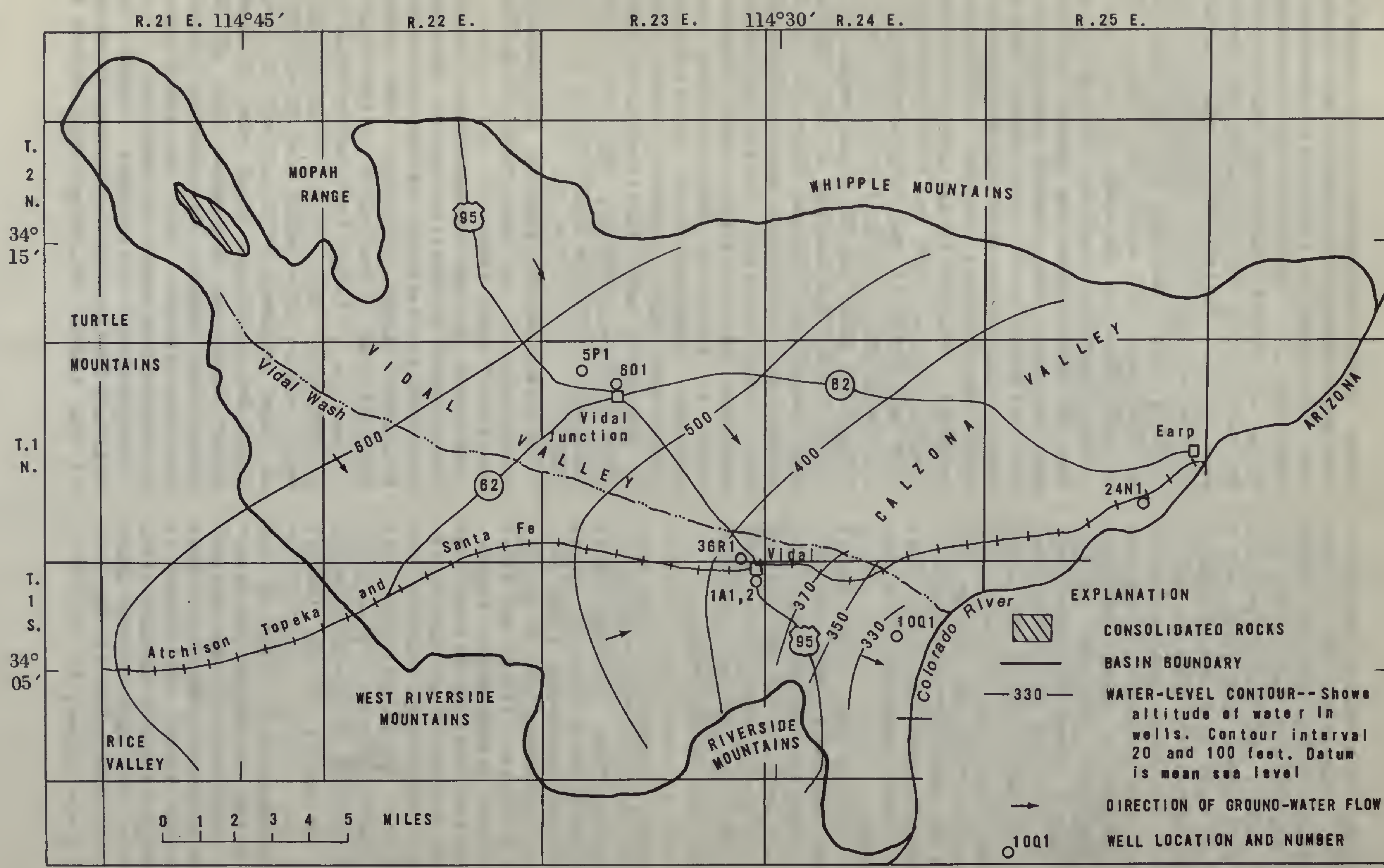
The climate of the area is similar to that of the surrounding desert valleys, hot and dry. Mean annual precipitation in the basin is 4 to 6 inches (Rantz, 1969). Some flash flooding occurs along Vidal Wash during periods of intense rainfall. Mean daily minimum and maximum temperatures are 42°F and 64°F in January, 82°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).

Depth to water in the basin ranges from 14 ft below land surface at well 1N/25E-24N1, near the Colorado River, to 268 ft below land surface at well 1N/23E-8D1, near Vidal Junction. Well 1S/23E-1A1, near the town of Vidal, had a reported depth to water of 240 ft below land surface. Another well near Vidal, 1N/23E-36R1, had a measured water level of 246.35 ft below land surface in March 1962 (Giessner, 1963b); the water level was 246.75 ft below land surface in April 1978.

The ground-water gradient is generally southeasterly. No known barriers inhibit the ground-water flow.

Recharge to the Calzona-Vidal Ground-Water Basin is infiltration of precipitation in the basin and on the surrounding mountain ranges. Because the annual precipitation in the basin is less than 6 inches the recharge from infiltration of precipitation is small. Some ground-water enters the basin from Rice Valley on the southwest. There may be some localized recharge from the Colorado River along the northeast edge of the basin where pumping has caused a lowering of water levels. Data are insufficient to compute the amount of recharge.

Ground-water discharges into the Colorado River along the southeast border of the basin. Discharge also occurs by



Water-level contours from W.R. Moyle, Jr. (1974)
Basin boundary approximated from California Department of Water Resources (1975)

FIGURE 8.--Ground-water basin, Calzona-Vidal Valley (7-41, 7-42).

the pumping of a few wells near Vidal Junction and several wells near Earp.

Storage.--Drillers' logs of wells in the basin indicate a maximum aquifer thickness of 785 ft at well 1N/23E-5P1. An average aquifer thickness of 500 ft and an estimated average depth to water of 250 ft provided a saturated thickness of 250 ft, which was used in calculating storage. The specific yield is high in the older alluvium section at shallow depths; however, deposits of low permeability occur at depth, and this limits specific yield. After analyzing the available drillers' logs, a specific yield of 7 percent was assumed to be representative of the upper 500 ft of sediment. Using these values, the recoverable storage was estimated to be 3.5 million acre-ft for the basin.

Well yield.--Well yields range from 100 gal/min at well 1N/23E-5P1, near Vidal Junction, to 1,800 gal/min at well 1S/24E-10Q1, near the Colorado River. Most of the wells near the Colorado River have high yields, probably owing to their being drilled into the older alluvium deposited by the Colorado River. The wells in the Vidal Junction area are drilled into the deeper, less permeable formations and therefore have lower yields.

Water quality.--Water-quality data for domestic and irrigation wells near Vidal Junction and Vidal show a range in dissolved solids from 400 to 600 mg/L (Giessner, 1963b). In both areas the water is marginal for irrigation because of high percent sodium (average 85 percent). Water from wells in the Vidal area contains fluoride in excess of 9 mg/L, making it unsuitable for domestic use. The dissolved solids in the northern and northwestern parts of the basin range from 1,000 to 1,500 mg/L. This water is marginal for agricultural use and inferior for domestic use. The water from the upper part of the older alluvium near the Colorado River is of much better quality than the water at depth.

Basin development.--Past usage of the ground water was limited to approximately 50 acre-ft/yr by the Metropolitan Water District and some private parties (California Department of Water Resources, 1954). At present (1978) the ground water is used mainly for irrigation, with some limited domestic use. All the irrigation is near the Colorado River. The domestic use is near Vidal Junction. The Atchison, Topeka and Santa Fe Railway Co. also uses water from wells 1S/23E-1A1 and 1A2 near Vidal.

Basin assessment.--The basin meets the criteria for a powerplant site. The limited pumping in the northeastern part of the basin is near the Colorado River, which serves as the recharge source for localized pumping depressions in that part of the basin. Thus, large withdrawals in other parts of the basin would probably not affect those wells. If large quantities of water were pumped from the basin, the resulting water-level declines and pumping depressions would probably lower the water levels in the wells at Vidal and Vidal Junction. Some or all the ground water that is moving out of the basin to the southwest may be recovered.

BASINS CONSIDERED SUITABLE, WITH QUALIFICATIONS, FOR POWERPLANTS

The basins that are classified suitable, with qualifications, are those basins that apparently meet the established criteria but in some respect the data are not conclusive. Table 2 summarizes the hydrologic characteristics of those basins and is followed by a brief description and evaluation of each basin.

Coyote Lake Valley (6-37)

Basin description.--The Coyote Lake Valley Ground-Water Basin (fig. 9) is in the Coyote Lake Hydrologic Unit (W-18.00). The basin is in the central part of San Bernardino County about 30 mi northeast of Barstow. It is irregular in shape and encompasses about 150 mi^2.

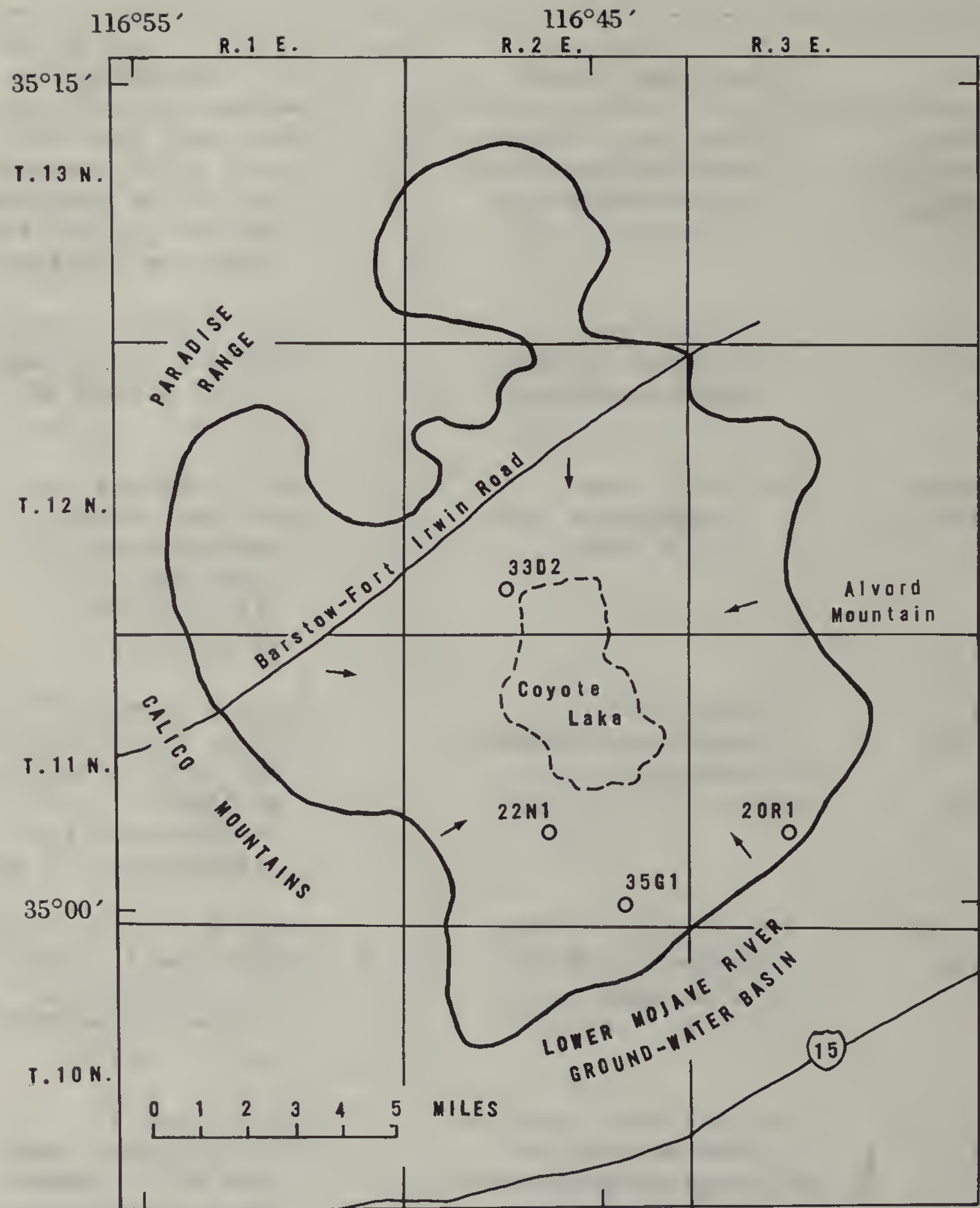
Access to the area is provided by the Barstow-Fort Irwin Road and by several dirt roads that enter the basin from the northwest and southeast. The basin is

TABLE 2.--Basins considered suitable

Basin name and number	Basin size (mi^2)	Storage (acre-ft)	Well yield
Coyote Lake Valley 6-37	150	5,913,000 reported by Mojave Water Agency.	Data inconclusive.
Harper Valley 6-47	500	2,497,000 reported by Mojave Water Agency.	Maximum of about 3,000 gal/min.
Panamint Valley 6-58	360	About 6,000,000.	Data inconclusive.
Rice Valley 7-4	300	2,500,000, assuming an average saturated thickness of 200 ft.	No data.
Dale Valley 7-9	260	3,500,000, assuming an average saturated thickness of 300 ft.	Data inconclusive.
Palo Verde Mesa 7-39	280	5,000,000, assuming an average saturated thickness of 300 ft.	Average 1,650 gal/mi with a maximum of 2,750 gal/min.

vith qualifications, for powerplants

Water quality	Basin development	Remarks
Dissolved solids range from 310 to 2,480 mg/L. Locally high in fluoride and boron.	Agricultural development limited to the southeastern part of basin.	Additional data on well yield and water quality in the southeastern part of the basin are required.
Dissolved solids up to 2,000 mg/L. Locally high in fluoride and boron.	About 500 acres irrigated in 1961; less since then.	Well yield and water quality vary considerably within the basin.
Dissolved solids range from 518 to 272,000 mg/L.	No wells known to be in use in the basin.	Well yield may be low because of considerable quantities of silt and clay in aquifer.
Dissolved solids up to 2,610 mg/L. Locally high in fluoride and boron.	Virtually no development of the basin.	Judging from drillers' logs, the well yield may be low near the periphery of the basin but higher near the center.
Dissolved solids range from 1,120 to 326,000 mg/L.	Development limited because of poor water quality.	Judging from drillers' logs, well yields may be highest in the northwestern part of basin.
Dissolved solids up to 4,500 mg/L.	Agricultural development expanding in part of the basin.	Development is limited to a small part of the basin; water quality may limit the expansion.



Basin boundary approximated from California Department of Water Resources (1964b)

EXPLANATION

BASIN BOUNDARY

DIRECTION OF GROUND-WATER FLOW

35G1 WELL LOCATION AND NUMBER

FIGURE 9.--Ground-water basin, Coyote Lake Valley (6-37).

bordered on the northwest by the Paradise Range, on the northeast by low hills, on the east by Alvord Mountain, on the southeast by a topographical divide that separates it from the lower Mojave River Valley Ground-Water Basin, and on the southwest by the Calico Mountains. Coyote Lake, a playa, is in the central part of the basin at an altitude of about 1,700 ft.

Mean annual precipitation in the basin is about 5 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 33°F and 60°F in January, 72°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--Quaternary alluvium covers most of the basin floor and is at least 584 ft thick (California Department of Water Resources, 1964b).

Water levels range from 57 ft below land surface in well 11N/2E-35G1 to above land surface on the north and west edges of Coyote Lake. Historical water-level data indicate that the water level has not declined significantly.

Water-level altitudes indicate that the movement of ground water is from the perimeter of the basin toward Coyote Lake.

Recharge to the aquifer is by precipitation in the basin and by underflow from adjacent basins. Because of low annual precipitation and high temperatures, recharge from precipitation is very small. Water-level data indicate underflow into Coyote Lake Valley Ground-Water Basin from basins on the northwest, northeast, and southeast. The California Department of Water Resources (1967) estimated 1,000 acre-ft/yr of underflow moves into the basin from the Lower Mojave River Ground-Water Basin.

Ground-water discharge occurs by evaporation from the shallow water table and by springflow, flowing wells, and pumping. Some wells are used for irrigating alfalfa in the southeastern part of the basin, and several wells are used for irrigating alfalfa in the Lower Mojave River Ground-Water Basin. Some underflow may be moving out of Coyote Lake Valley Ground-Water Basin into the pumping depression caused by these wells.

Storage.--The Mojave Water Agency (written commun., 1978) estimated that 5,913,000 acre-ft of ground water is in storage in the basin. This estimate assumed that the average thickness of saturated alluvial deposits is 366 ft with an average specific yield of 17 percent.

Well yield.--Few data exist on maximum well yields in the basin. Wells south of the basin yield as much as 1,800 gal/min. Well yields in the basin probably are less because of finer grained aquifer material toward Coyote Lake. Test wells would have to be drilled to determine maximum well yields.

Water quality.--The dissolved-solids concentration in ground water in the basin is generally low ranging from 310 mg/L in well 11N/3E-20R1 to a high of 2,480 mg/L in well 11N/2E-22N1. High concentrations of fluoride and boron make the water generally unsuitable for domestic and agricultural purposes. A water sample collected in 1953 from well 12N/2E-33D2 had a fluoride concentration of 10 mg/L. A water sample collected in 1932 from well 11N/2E-22N1 had a boron concentration of 34,000 µg/L (Dyer and others, 1963).

Some of the water in the southeastern part of the basin may be suitable for domestic and agricultural purposes; sufficient water-quality data are not available to delineate these areas. Water high in dissolved solids probably exists below Coyote Lake. This is typical of water quality under most dry lakes in southern California.

Basin development.--Little ground water is being consumptively used in the basin. There may be as many as 25 wells in the basin but most are abandoned. A few wells are used to irrigate alfalfa near the southeast edge of the basin. Future agricultural expansion could extend farther into the basin toward Coyote Lake. Agricultural expansion will depend mainly on the concentration of boron and on the percent sodium in the water of this area.

Basin assessment.--The Coyote Lake Valley Ground-Water Basin is considered to be suitable, with qualifications, for a powerplant site, the qualifications being limited data on well yield and the possibility of expanding agricultural development that would result in competitive demands for the existing ground water.

Because of limited recharge to the basin, most of the water used for powerplant cooling would come from storage. This would result in declining water levels and the development of pumping depressions. If substantial quantities of water were pumped from the southeastern part of the basin, the resulting pumping depression could extend into the Lower Mojave River Ground-Water Basin. This would draw more recharge into the basin. Water could be drawn into the pumping depression from under Coyote Lake, which might result in an increase in dissolved solids in the water being pumped.

Harper Valley (6-47)

Basin description.--The Harper Valley Ground-Water Basin (fig. 10) is in the Harper Hydrologic Subunit (W-28.D2). The basin is in the northwestern part of San Bernardino County, with a small part extending into Kern County. The basin is irregularly shaped and encompasses about 510 mi^2.

Access to the basin is by U.S. Highway 395 from the north and south and by State Highway 58 from the east and west. The basin is bordered on the northeast by Fremont Peak and the Gravel Hills, on the southeast by low hills and Iron Mountain, and on the west by a topographical divide that separates it from Antelope Valley Ground-Water Basin. The altitude of the basin floor ranges from about 2,900 ft in the northwest to about 2,000 ft at Harper Lake, a playa.

Mean annual precipitation in the basin is 5 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 32°F and 61°F in January, 72°F and 104°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--Quaternary alluvium, composed of unconsolidated gravel, sand, silt, and clay, is exposed over most of the basin floor. The coarser grained deposits are generally predominant in the alluvial fans and at higher altitudes and finer deposits are generally predominant at lower altitudes, such as at Harper Lake.

Water levels in the basin range from 283 ft below land surface in well 11N/7W-13R1 to 3 ft below land surface in well 11N/3W-30A1 (Moyle, 1971). The water level in well 11N/7W-13R1 declined 14 ft between 1952 and 1968, probably owing to withdrawals in the Kramer Junction area. The water level in well 11N/4W-30P1 declined 24 ft between 1953 and 1969 (Moyle, 1971); this is typical of the declines in the area extending about 2 mi west of Harper Lake and is caused by withdrawals for agricultural uses. Water levels in the rest of the basin have not declined significantly.

Water-level altitudes indicate that the ground water is moving from the perimeter of the basin toward the area west of Harper Lake where withdrawals have created a slight ground-water depression. The Lockhart fault, which trends northwestward (fig. 10), may partially obstruct the flow of ground water.

Recharge to the ground-water basin occurs by deep percolation of precipitation in the basin and by underflow from adjacent basins. Little recharge is provided by precipitation, because of low annual precipitation and high evaporation in the basin. Water levels indicate that underflow may be entering the basin from the Middle Mojave River Ground-Water Basin on the southwest and possibly from Cuddeback Valley Ground-Water Basin on the north.

Ground-water discharge occurs from evapotranspiration of shallow ground water in the Harper Lake area and from consumptive use by irrigated alfalfa on the west side of Harper Lake.

Storage.--The Mojave Water Agency (written commun., 1978) estimated that 2,497,000 acre-ft of water is in storage

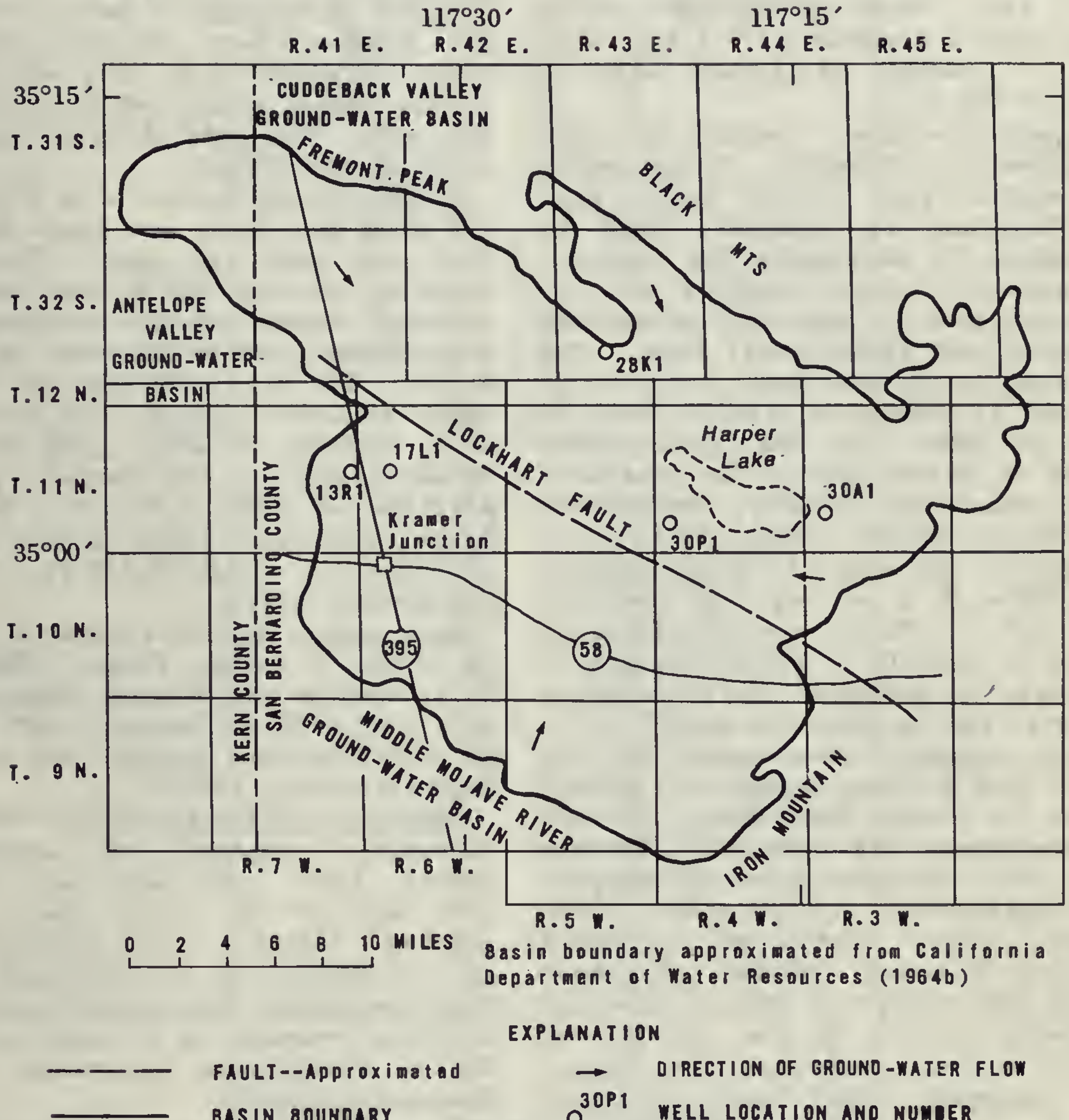


FIGURE 10.--Ground-water basin, Harper Valley (6-47).

in the basin. Thickness of the alluvium was assumed to range from 220 to 460 ft and the specific yield from 7 to 22 percent.

Well yield.--Wells in the irrigated area west of Harper Lake yield as much as 3,000 gal/min with an average of about 1,000 gal/min. Wells in the northern and western parts of the basin yield considerably less. Well 32S/43E-28K1 yields 3 gal/min with a drawdown of 9.5 ft. Well 11N/6W-17L1 yields 48 gal/min with a drawdown of 270 ft.

Water quality.--Water quality in the basin varies considerably. Ground water in the western part of the basin, near Kramer Junction, is generally high in boron, making it unsuitable for agricultural purposes. Water quality in the northwestern part is generally acceptable for domestic and agricultural uses. The ground water in the area north and east of Harper Lake is generally high in boron or fluoride or both. In the agricultural area west of Harper Lake it is generally high in dissolved solids. Dissolved-solids concentrations range from about 2,000 mg/L at the edge of Harper Lake to about 1,000 mg/L 2 mi west of the lake (Moyle, 1971). There are insufficient data on water quality in the southern part of the basin to determine its suitability for domestic and agricultural uses.

Basin development.--Development in the basin has been minimal except in a 10 mi^2 area west of Harper Lake where agricultural development has occurred. Between 1954 and 1957, the peak years of agricultural development, 2,300 acres were irrigated. Since that time irrigated acreage has declined; in 1961 only about 500 acres were irrigated. Future development depends mainly on the quality of water in various parts of the basin.

Basin assessment.--The basin is considered to be suitable, with qualifications, for a powerplant site, the qualifications being unknown water quality and low well yields in various parts of the basin. If substantial quantities of ground water were pumped for powerplant cooling, water levels would decline and a pumping depression would develop around the well field. A pumping depression near Harper Lake might cause the water from under Harper Lake to move into the depression. This would result in increasing dissolved solids in the pumped water.

Panamint Valley (6-58)

Basin description.--The Panamint Valley Ground-Water Basin (fig. 11) is in the Panamint Hydrologic Subunit (W-20.FO) in the southern part of Inyo County. The basin is about 55 mi long and 12 mi wide at the widest point and encompasses about 360 mi^2. The axis of the basin trends north-northwestward.

Access to the basin is by State Highway 178 from the south and State Highway 190 from the east and west. The basin is bordered on the north and east by the Panamint Range, on the southwest by the Slate Range, and on the west by the Argus Range. Two dry lakes are in the basin: Upper Panamint Lake in the northern part at an altitude of about 1,500 ft and Lower Panamint Lake in the southern part at an altitude of about 1,000 ft. Between the lakes the land rises gradually to an altitude of about 1,800 ft, forming a topographic divide.

Mean annual precipitation in the basin is about 5 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 32°F and 60°F in January, 70°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--Quaternary alluvium, composed of unconsolidated gravel, sand, silt, and clay, is exposed over most of the basin floor. The dry lakebed deposits are generally finer grained consisting of fine sand, silt, and clay containing some evaporite salts. The alluvium extends to a depth of at least 800 ft (California Department of Water Resources, 1964b).

The water level in well 18S/42E-22B1 was 125 ft below land surface in 1953, the deepest water level on record in the basin. The water level in well 22S/44E-10D1, on the east side of Lower Panamint Lake, was 3 ft below land surface in 1955. Water levels indicate that ground water in the basin moves toward Lower Panamint Lake.

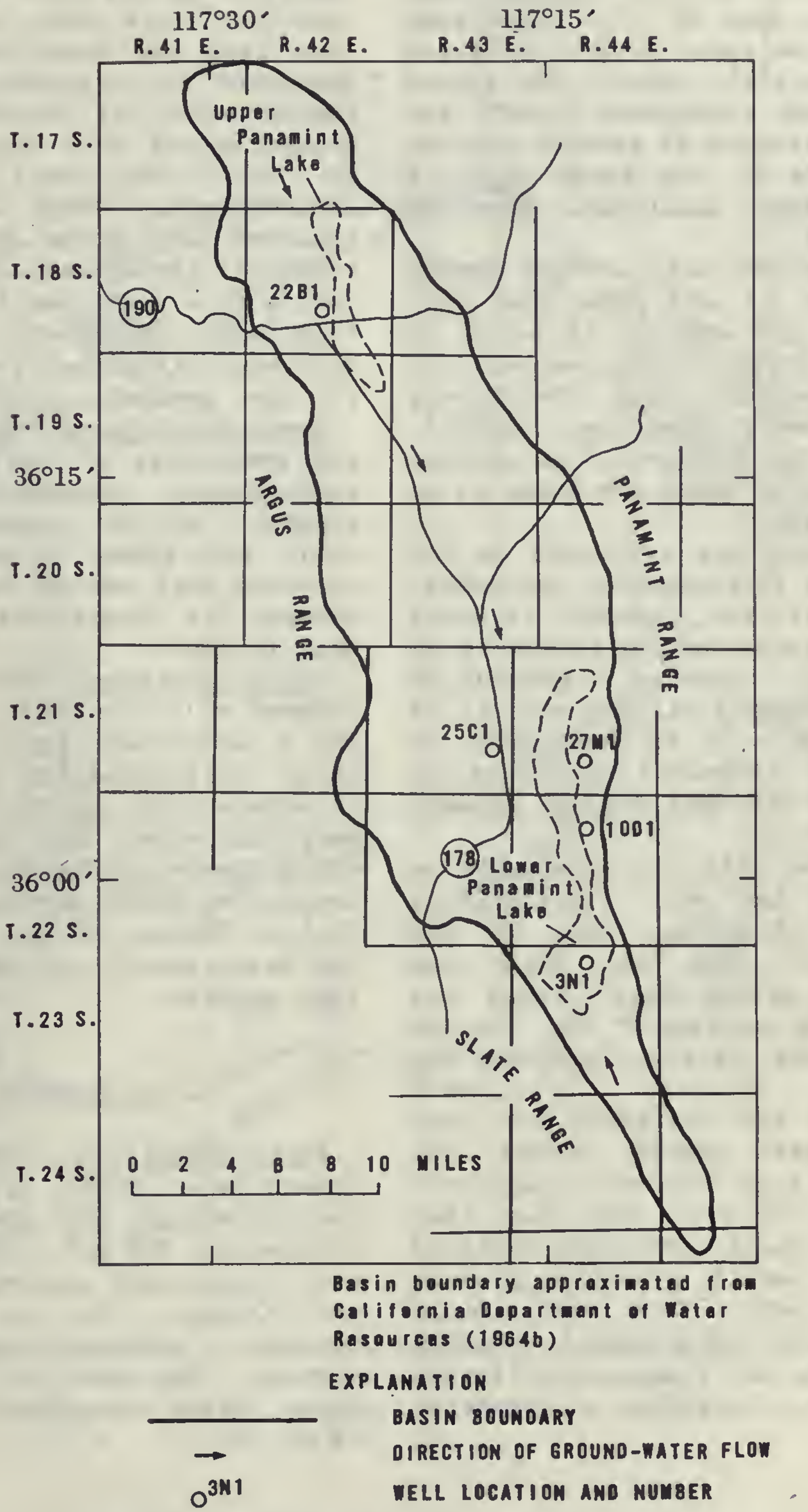


FIGURE 11--Ground-water basin, Panamint Valley (6-58).

Ground-water recharge occurs from underflow into the basin from the south and from an adjacent valley on the northeast. Recharge is also obtained from percolation of rainfall runoff in the basin. When rainfall is light most of it is evaporated before reaching the water table. A larger percentage of rainfall enters the ground when rainfall and consequent runoff are intense. The existence of several springs on the east side of the basin suggests recharge at higher altitudes, possibly outside the basin.

Discharge of ground water occurs mostly from evaporation at and near the land surface. About 100 acre-ft of water is being used for domestic purposes and for irrigation of pasture land (California Department of Water Resources, 1964b). All this water is obtained from springs and surface flow; no wells are known to be in use in the basin.

Storage.--No data are available on the quantity of water in storage in the basin. In a basin of this size, however, it would only require a saturated thickness of 65 ft and a specific yield of 7 percent to contain the required 1 million acre-ft of water in storage. It is reasonable to assume that the saturated thickness is nearer to 400 ft and that storage exceeds 6 million acre-ft.

Well yield.--The only data available on well yield are for well 21S/43E-25C1, which produced 35 gal/min when it was drilled in 1955. The well depth was 82 ft, and the static water level was 62 ft below land surface. The limited saturated thickness, in part, accounts for the low yield.

Drillers' logs are available for five wells in the basin (Moyle, 1969b). An analysis of the logs indicates considerable quantities of silt and clay that would limit well yield. Properly designed wells, however, would probably produce 500 gal/min or more. Test wells would have to be drilled and pumped to provide the transmissivity and storage-coefficient data required for calculation of potential well yields.

Water quality.--There is a considerable range in water quality in the basin. The dissolved-solids concentration in a water sample collected in 1960 from well 21S/44E-27M1 was 518 mg/L (Moyle, 1969b). The source of this water was probably underflow from the east, which had not been subjected to evaporation and subsequent concentration of dissolved solids. Dissolved solids in a water sample collected in 1953 from well 23S/44E-3N1 were 272,000 mg/L. This well is in Lower Panamint Lake where evaporation has concentrated the dissolved solids. Dissolved solids in a water sample collected in 1961 from well 21S/43E-25C1 were 1,150 mg/L. This water is probably more representative of the general quality in the basin.

Basin development.--Lack of good water and remoteness of the area have hindered agricultural, industrial, and population growth. At the present time (1978) no wells are known to be in use. It is unlikely that new and substantially larger demands for ground water will occur in the near future.

Basin assessment.--The basin is considered to be suitable with qualification for a powerplant site, the qualification being the probability of low well yields. If substantial quantities of ground water were extracted for powerplant cooling, water levels would decline and a pumping depression would develop around the well field. Because of the limited recharge to the basin nearly all the water would come from storage.

Rice Valley (7-4)

Basin description.--The Rice Valley Ground-Water Basin (fig. 12) is in the Rice Hydrologic Unit (X-16.00). The basin encompasses 300 mi^2 in northeastern Riverside County and southeastern San Bernardino County. It is a desert basin of internal drainage with no perennial streams. The basin is roughly circular in shape, being approximately 18 mi long and 17 mi wide.

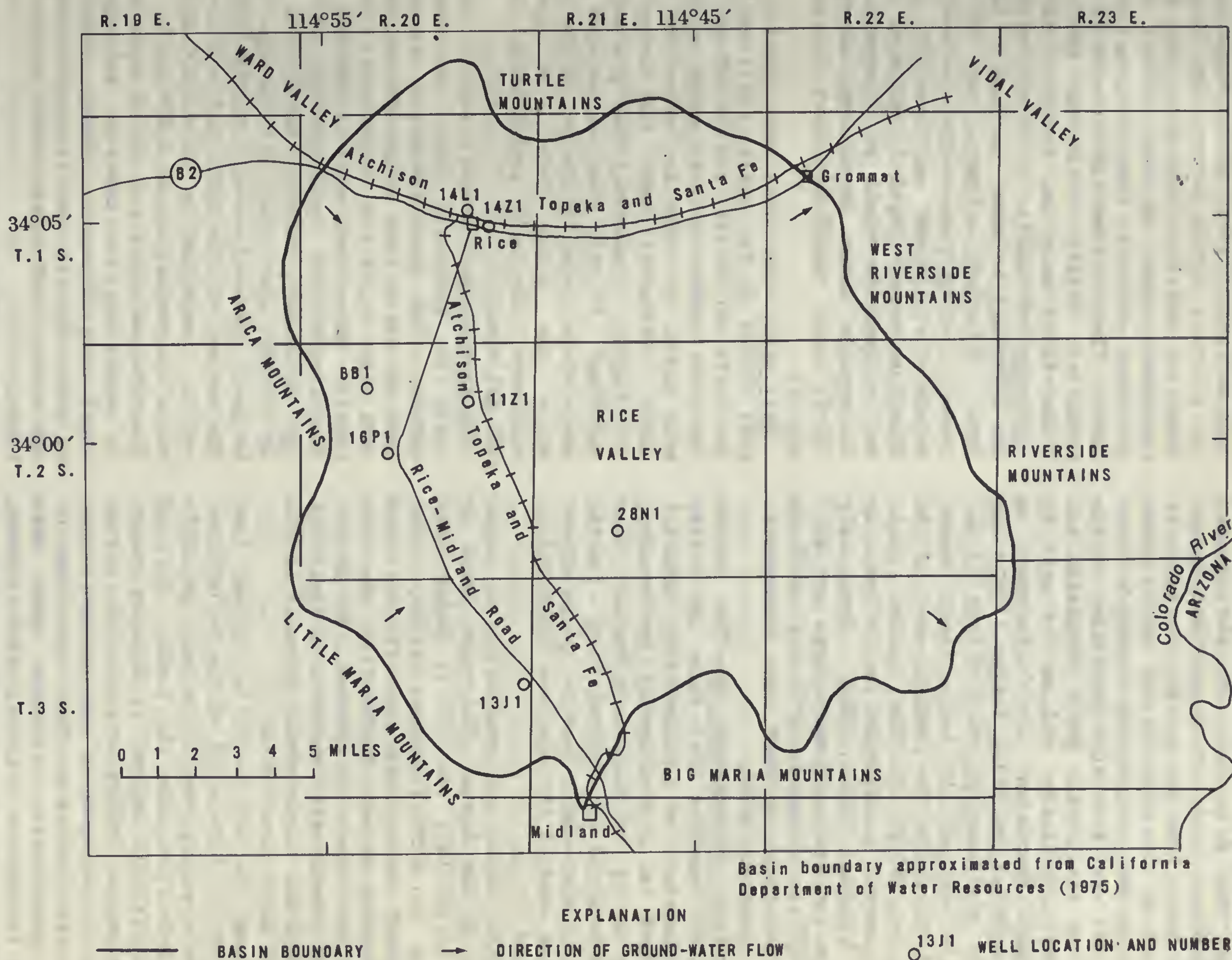


FIGURE 12.--Ground-water basin, Rice Valley (7-4).

Access to the basin is provided by State Highway 62, which traverses the basin in an east-west direction, and the unpaved Rice-Midland Road, which provides access to the basin from the south. The basin is bordered on the north by the Turtle Mountains, on the east by the Riverside Mountains and West Riverside Mountains, on the south by the Little Maria Mountains and Big Maria Mountains, and on the west by the Arica Mountains. It is bordered on the northeast by Vidal Valley (7-42) and on the northwest by Ward Valley (7-3). The altitude of the basin floor ranges from 1,040 ft in the southern part of the basin to 700 ft in the central part.

Mean annual precipitation in the basin is about 4 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 42°F and 60°F in January, 82°F and 104°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--The unconsolidated deposits that form the valley fill consist of sedimentary material deposited in a continental environment, mainly during the Quaternary Period. Most of the material was water-laid as alluvial fan, stream channel, lake, or playa deposits, but some of the sand was deposited by the wind.

Limited data are available on water levels in the basin. The water level in well 1S/20E-14Z1 was 370 ft below land surface in 1933 (Giessner, 1963b). The shallowest water level was 137 ft below land surface at well 2S/20E-11Z1; the date of the measurement is unknown. The direction of ground-water movement in the basin is difficult to determine because of the lack of water-level data.

Recharge to the basin is derived from percolation of rainfall on the basin floor and surrounding mountains and possibly from underflow into the basin. Most of the rainfall (4 inches) is lost by evapotranspiration before reaching the water table. An analysis of the limited water-level data indicates that there may be some ground-water recharge from Ward Valley through the alluvial divide between the basins. Total recharge to the basin has been estimated to be 500 acre-ft/yr (California Department of Water Resources, 1975).

Discharge from the basin occurs as underflow into Vidal Valley on the northeast and possibly out of the basin through the alluvial divide between the Riverside Mountains and Big Maria Mountains in the southeast corner of the basin. Little discharge results from pumping in the basin. The California Department of Water Resources (1975) estimated that only 1 acre-ft of water was extracted in 1952.

Storage.--Estimates of water in storage are difficult to make, because of lack of data. A rough estimate can be made, however, using conservative estimates of saturated thickness and specific yield. Using an average depth to water of 300 ft and a specific yield of 7 percent, the recoverable water in storage above the 500-ft depth would be about 2.5 million acre-ft.

Well yield.--No data are available on well yields in the basin. Drillers' logs for wells 1S/20E-14L1 and 1S/20E-14Z1 show that the sediments that would yield the most water to wells are above the water table. Sediments below the water table are tightly compacted, fine-grained sand and clay. If this same sequence of sediments occurs near the center of the basin, where the water level is probably shallower, the well yields might exceed 500 gal/min.

Water quality.--Ground water in the basin is generally high in dissolved solids. The dissolved-solids concentration in water from wells 1S/20E-14L1 and 14Z1 was 2,170 and 2,340 mg/L, respectively. Water from well 2S/20E-8B1 had a dissolved-solids concentration of 2,610 mg/L (Giessner, 1963b). Water from wells 2S/20E-16P1 and 3S/20E-13J1 is reported to be good. Water from well 2S/21E-28N1 near the center of the basin had a dissolved-solids concentration of 1,820 mg/L, a boron concentration of 2,800 μg/L, and a fluoride concentration of 1.8 mg/L, making it unsuitable for domestic and agricultural uses (Giessner, 1963b). Virtually no water-quality data are available for the eastern and northeastern parts of the basin.

Basin development.--Development of the basin has been limited to supplies for mining, railroad, and domestic purposes. Wells that belong to the railroad have been abandoned, and mining activity has decreased. There is no agricultural development in the basin, because the water quality is poor.

Basin assessment.--This basin is considered to be suitable, with qualification, for a powerplant site, the qualification being lack of data on well yield. Because of limited recharge to the basin from Ward Valley, nearly all the water extracted from the basin must come from storage. Pumping large quantities of water for powerplant cooling will cause water-level declines and the formation of pumping depressions in the well-field area. These declines may cause a change in the direction of ground-water flow that would probably curtail underflow out of the basin into Vidal Valley.

Dale Valley (7-9)

Basin description.--The Dale Valley Ground-Water Basin (fig. 13) is in the Dale Hydrologic Subunit (X-9.BO). The basin is in southeastern San Bernardino County and covers about 260 mi^2. Drainage is internal, and there are no perennial streams.

Access to the area is provided by Amboy Road, Twentynine Palms Highway (State Highway 62), Gold Crown Road, and a few unpaved roads.

The basin is bordered on the north by the Bullion Mountains, on the east by the Sheep Hole Mountains, on the south by the Pinto Mountains, and on the west by the Twentynine Palms Valley. Dale Lake, a dry playa, is in the southeastern part of the basin. Altitudes in the basin range from 2,000 ft above sea level near the base of the mountains to 1,200 ft above sea level around the perimeter of Dale Lake.

The climate is similar to most of the surrounding desert basins. Mean annual precipitation in the basin is about 4 inches (Rantz, 1969). Mean daily minimum and maximum temperatures are 36°F and 62°F in January, 76°F and 104°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--The main water-bearing units in the area are alluvial deposits that underlie the sand veneer and fan deposits that fill local structural depressions to various depths. The alluvial deposits consist of lenticular beds of sand, gravel, silt, and clay, except near the mountains where they consist principally of coarse-grained, angular rock detritus.

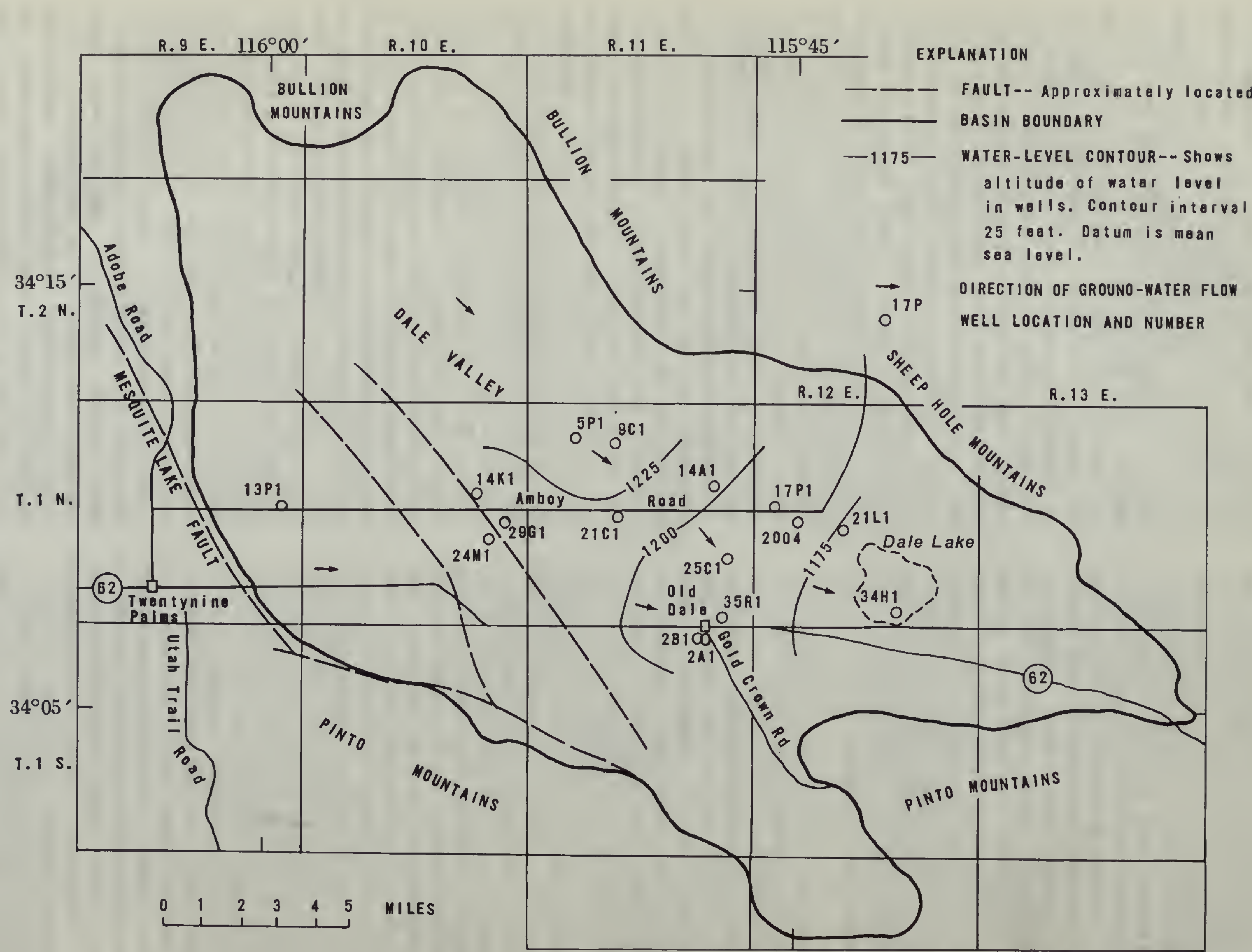
Ground water flows southeastward toward Dale Lake. Movement of the ground water is impeded by three faults that separate the main valley into ground-water subbasins (fig. 13). The three faults act as ground-water barriers that cause a difference in water levels on each side of the faults. Water levels on the east side of each fault are deeper than on the west side (Moyle, 1961). The Mesquite Lake fault, on the west edge of the valley, causes water-level differences of as much as 240 ft. Water levels measured in the basin ranged from 344.3 ft below land surface at well 1N/10E-14K1 to 9.05 ft below land surface at well 1N/12E-21L1.

Ground-water recharge to the basin is supplied mainly by underflow from the Twentynine Palms basin, west of Dale Valley. The underflow is small because the Mesquite Lake fault impedes the ground-water movement. A small quantity of recharge also occurs by runoff from the slopes of the surrounding mountains and by the direct infiltration of precipitation in the basin.

There is no known outflow of ground water from the basin. The only discharge of ground water is by evapotranspiration from the Dale Lake playa.

Storage.--Drillers' logs were used to determine aquifer thickness and specific yield. Well 1N/12E-20D4 was drilled to a depth of 1,190 ft and bedrock was not reached. Only the upper 500 ft of sediments were used in determining storage. Specific yield was estimated to be at least 7 percent. Average depth to water was estimated to be 200 ft below land surface; therefore, a saturated thickness of 300 ft was used in calculating storage. Using these values the storage was concluded to be 3.5 million acre-ft.

Well yield.--The well-yield data are sparse. Yields have been reported to average 267 gal/min (Bader, 1969). An



Ground-water contours from W.R. Moyle, Jr. (1961) Basin boundary approximated from California Department of Water Resources (1975)

FIGURE 13.--Ground-water basin, Dale Valley (7-9).

analysis of drillers' logs indicates that expected yields in and around Dale Lake playa would be small. The small yields are caused by the fine sand and clay layers of the formation. In the northwestern part of the basin, expected well yields should be greater for properly designed wells because the aquifer consists of coarser sediments.

Water quality.--The water quality of the basin is generally unsuitable for domestic and agricultural uses. Dissolved solids range from 1,120 mg/L at well 1S/11E-2A1 to 326,000 mg/L at well 1N/12E-34H1. The water underlying Dale Lake is highly saline and formerly was extracted for salt production. The water north of the lake has a dissolved-solids concentration of less than 2,000 mg/L, but fluoride levels are too high for domestic use. Well 1N/11E-35R1 had a dissolved-solids concentration of 1,450 mg/L and a fluoride level of 6.0 mg/L reported in December 1957. Percent sodium for this well was 81; therefore, the water is unsuitable for irrigation use. The high sodium levels are characteristic of ground water throughout the basin (Moyle, 1961).

Basin development.--The poor quality of the water in the basin has limited the development of ground water. About 100 wells have been drilled in the basin, most of them for Dale Chemical Industries, Inc. The Dale company pumped approximately 1,300 acre-ft of brine from beneath Dale Lake. The plant closed in 1949, however, and no brine has been pumped since that time. Domestic use of the ground water has been small because of the high concentrations of dissolved solids. Residents of the scattered homesites, which are used principally on weekends, obtain their water supply from outside sources, usually by tank truck. No agricultural use of the ground water has occurred because of the high boron and high percent sodium levels.

Basin assessment.--The basin is considered suitable, with qualification, for a powerplant site, the qualification being questionable well yields. An analysis of drillers' logs indicates that yields above 500 gal/min may be expected for wells in most parts of the basin. Drillers' logs indicate considerable quantities of silt and clay in wells near Dale Lake; wells in this area would probably not yield 500 gal/min.

A well field near Dale Lake would probably eventually draw water from under the lake. This might result in increasing the dissolved solids in the pumped water, because the water under Dale Lake is extremely saline.

Palo Verde Mesa (7-39)

Basin description.--The Palo Verde Mesa Ground-Water Basin (fig. 14) is in the Palo Verde Hydrologic Subunit (X-15.DO). The basin covers 280 mi^2 in the southeastern part of Riverside County, west of Blythe. It is about 25 mi long and has a maximum width of about 15 mi; its axis trends north-south.

Access to the area is by Interstate Highway 10, U.S. Highway 95, and the Midland Road. The basin is bounded on the north by the Big Maria Mountains and Little Maria Mountains, on the west by the McCoy Mountains and Mule Mountains, and on the south by the Palo Verde Mountains. The eastern boundary is the Palo Verde Valley.

Altitudes on the basin floor range from about 300 ft, at the flood-plain boundary, to about 1,000 ft at the base of the mountains in the northwestern part of the basin.

The Palo Verde Mesa has a typical desert climate. Mean annual precipitation in the basin is about 4 inches (Rantz, 1969). During periods of intense rainfall, flash flooding occurs in the McCoy Wash area. Mean daily minimum and maximum temperatures are 42°F and 68°F in January, 80°F and 108°F in July (National Oceanic and Atmospheric Administration, 1974).

Hydrologic characteristics.--Measured depths to water ranged from 139.2 ft below land surface at well 7S/21E-14A1 to 230 ft below land surface at well 5S/22E-28C2. Water levels are shallower along the edge of the flood plain. The average depth to water for wells in the McCoy Wash area is about 200 ft below land surface. In the lowest parts of the mesa, near the flood-plain boundary, average depth to water is about 100 ft below land surface.

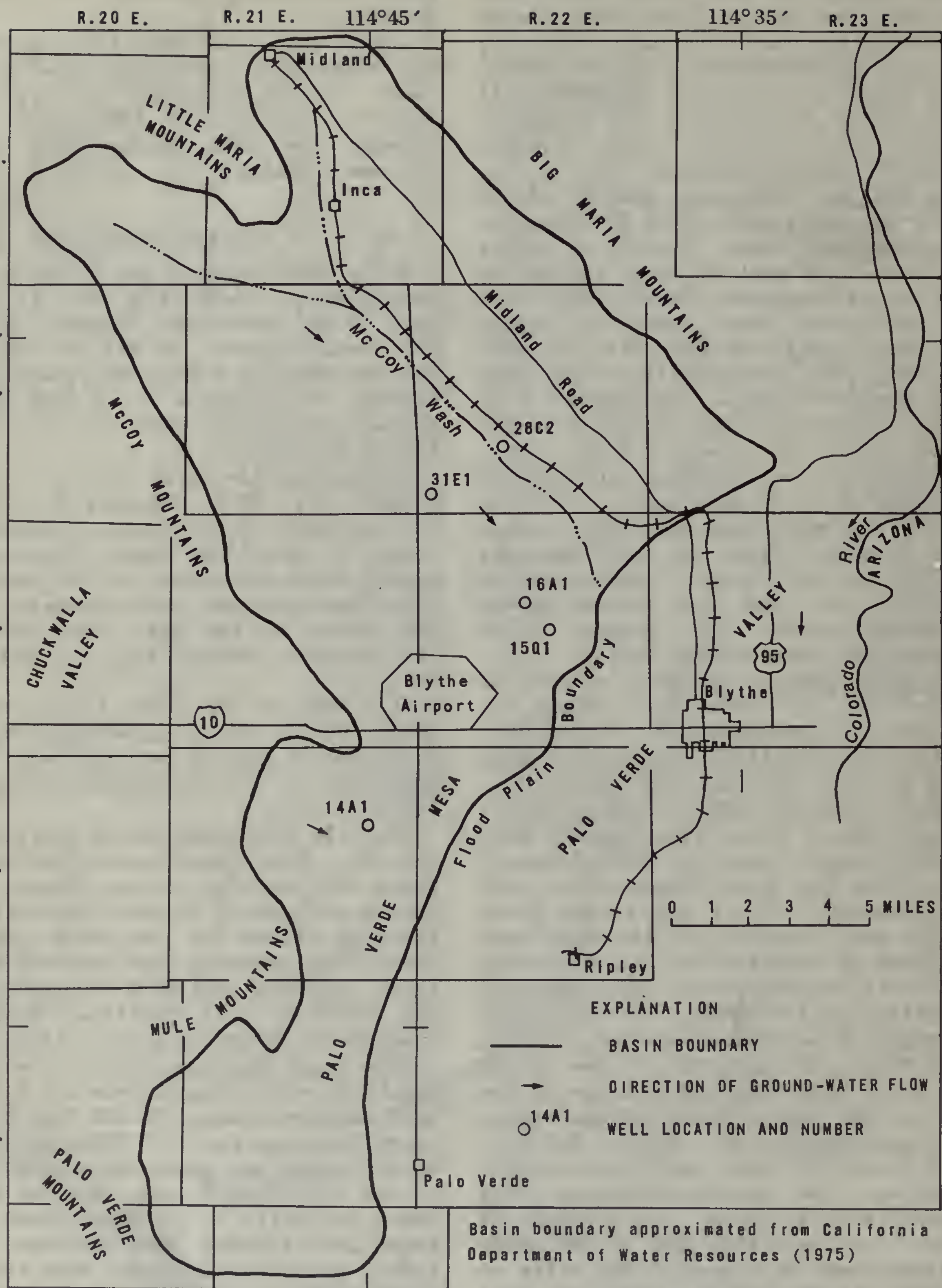


FIGURE 14.--Ground-water basin, Palo Verde Mesa (7-39).

Ground-water movement in the basin is southeastward. No known barriers or faults inhibit the flow of ground water.

Ground-water recharge is by underflow from Chuckwalla Valley, estimated to be 400 acre-ft/yr (Metzger and others, 1973). Recharge also is supplied by infiltration of precipitation in the basin and on surrounding mountains. Total annual recharge to the mesa is estimated to be 800 acre-ft/yr (California Department of Water Resources, 1975).

Discharge of ground water occurs as outflow to the Palo Verde Valley and by pumping. No estimate of total discharge has been made.

Storage.--Estimates of ground water in storage were based on data from drillers' logs and water-level measurements. Assuming an average saturated thickness of 300 ft and a specific yield of 10 percent, the usable storage in the basin is about 5 million acre-ft. About half of the usable storage is in the McCoy Wash part of the basin.

Well yield.--Well yields for the basin average 1,650 gal/min (California Department of Water Resources, 1975). The maximum yield reported is 2,750 gal/min from well 6S/22E-16A1. Large well yields are common for properly designed and developed wells near the edge of the flood plain. Well yields in the rest of the basin, where sand is the dominant lithology, are lower. Almost all wells in the McCoy Wash area have reported yields greater than 1,000 gal/min. The depth of these wells ranges from about 250 to 600 ft. The wells have 12- to 16-inch diameter casings.

Water quality.--A generalization on the basis of limited water-quality data is that the water has its best quality near the edge of the flood plain and becomes progressively higher in dissolved solids away from the flood plain. Also, water quality deteriorates with depth. Analyses of water from wells in the shallow alluvium indicate a range in dissolved solids from 730 to 3,100 mg/L. Wells perforated 700 to 900 ft below land surface have a dissolved-solids concentration of about 4,500 mg/L. Water from wells in the deeper formations also is of poor quality (Metzger and others, 1973).

Basin development.--The Palo Verde Mesa has had moderate to extensive ground-water development in the past. At least 48 large-diameter wells were drilled in the basin to service the Blythe Air Base (now Blyth Airport), nearby housing developments, and irrigation. Irrigated acreage on the Palo Verde Mesa directly west of Blythe is being expanded. More than half the wells in this area were drilled after 1966, which indicates an expansion of agricultural development. The closing of the Air Base, however, has eliminated all the development that had occurred in the McCoy Wash part of the basin. A cement plant near Midland is closed, and the railroad water stop at Inca was abandoned. At present (1978), the only wells being used are in the southeastern part of the wash near the flood plain.

Basin assessment.--This basin is considered suitable, with qualification, for a powerplant site; the qualification is the existing development in the area near the flood-plain boundary. A well field in this area would probably lower the water levels considerably in the existing wells. The most suitable area for pumping is the central part of the McCoy Wash, which extends from Midland to the edge of the flood plain northwest of Blythe.

BASINS WITH INSUFFICIENT DATA TO CLASSIFY FOR POWERPLANT SUITABILITY

Basins classified in the insufficient-data category (table 3) are those in which available data are inadequate to evaluate the basin with respect to the established criteria. As additional data become available, these basins could be included in one of the other categories.

BASINS CONSIDERED UNSUITABLE FOR POWERPLANTS

Basins were classified unsuitable if one or more of its hydrologic characteristics did not meet the established criteria. Table 4 is a list of the basins classified as unsuitable, with a brief explanation of the limiting criteria.

TABLE 3.--Basins with insufficient data to classify for powerplant suitability

Basin name and number	Basin size (mi^2)	Remarks
Eureka Valley 6-16	160	Only one well is known in the basin.
Saline Valley 6-17	210	Only limited data are available on wells in the basin. Water from Salt Lake has dissolved solids greater than 300,000 mg/L.
Lower Kingston Valley 6-21	290	Only one well is known in the basin; it was drilled to 425 ft and did not encounter water. Basin is also known as Valjean Valley Ground-Water Basin.
Upper Kingston Valley 6-22	270	Only a few wells are known in the basin; data are limited. Basin is also known as Shadow Valley Ground-Water Basin.
Riggs Valley 6-23	100	No wells are known in the basin.
Kelso Valley 6-31	370	Limited data are available on two wells at Kelso. No wells are known in other parts of the basin.

TABLE 3.--Basins with insufficient data to classify for powerplant suitability--Continued

Basin name and number	Basin size (mi^2)	Remarks
Broadwell Valley 6-32	120	Records indicate that 12 wells have been drilled in the basin; however, little or no data are available for these wells.
Ward Valley 7-3	770	Many wells have been drilled on Danby Lake for brine exploration and extraction. Little or no data are available for the remainder of the basin.
West Salton Sea 7-22	190	Only three wells are known in the basin. No data are available for these wells.
Amos Valley 7-34	220	Only two wells are known in the basin. No data are available for these wells.
Ogilby Valley 7-35	220	Records indicate that 13 wells have been drilled in the basin; however, little or no data are available for these wells.
Arroyo Seco Valley 7-37	430	Records indicate that 12 wells have been drilled in the basin; however, little or no data are available for these wells.
Chemehuevi Valley 7-43	440	Only two wells are known in the basin.

TABLE 4.--Basins considered unsuitable for powerplants

Basin name and number	Criteria eliminating basin				Explanation
	Storage	Well yield	Water quality	Basin development	
Mono Lake Valley 6-9				X	The basin is largely owned by the city of Los Angeles; water is exported for urban use in the Los Angeles metropolitan area.
Adobe Valley 6-10	X		X		The basin is small (60 mi^2); consequently, storage is limited. Water quality is generally suitable for domestic and irrigation uses.
Long Valley 6-11				X	Some parts of the basin are owned by the city of Los Angeles. Most of the basin is within the Inyo National Forest and is used for recreational purposes.
Owens Valley 6-12				X	The basin is almost entirely utilized as an underground reservoir which supplies water to the Los Angeles metropolitan area.
Back Springs Valley 6-13	X				The basin is small (50 mi^2); consequently, storage is limited.
Fish Lake Valley 6-14			X		Water quality is generally suitable for domestic and agricultural uses.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin: Storage	Well yield	Water quality	Basin development	Explanation
Deep Springs Valley 6-15	X		X		The basin is small (40 mi^2); consequently, storage is limited. Water quality in most of the basin is suitable for domestic and agricultural uses.
Death Valley 6-18				X	Basin is within Death Valley National Monument.
Wingate Valley 6-19				X	These basins are largely or totally within U.S. military reservations.
Red Pass Valley 6-24				X	
Bicycle Valley 6-25				X	
Avawatz Valley 6-26				X	
Leach Valley 6-27				X	
Pahrump Valley 6-28			X	X	Water quality in these basins is generally suitable for domestic and agricultural uses.
Mesquite Valley 6-29			X		

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin: Storage	Well yield	Water quality	Basin development	Explanation
Ivanpah Valley 6-30		X	X		The yield from wells is generally low. Water quality in the basin is generally suitable for domestic and agricultural uses.
Silver Lake Valley 6-34	X				The basin is small (40 mi^2); consequently, storage is limited.
Cronese Valley 6-35	X			X	More than half the basin is within a U.S. military reservation. Storage in the rest of the basin is probably less than 1 million acre-ft.
Langford Valley 6-36	X			X	Basin is within a U.S. military reservation.
Troy Valley 6-39				X	Ground water is being used for recreation.
Lower Mojave River Valley 6-40			X	X	Water quality in most of the basin is generally suitable for domestic and agricultural uses. Ground water is being used for urban, industrial, and agricultural purposes.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin: Storage	Well yield	Water quality	Basin development	Explanation
Middle Mojave River Valley 6-41			X	X	Water quality in most of the basin is generally suitable for domestic and agricultural uses. Ground water is being used for urban, industrial, and agricultural purposes.
Upper Mojave River Valley 6-42			X	X	Do.
El Mirage Valley 6-43			X		Water quality is generally suitable for domestic and agricultural uses, except in the immediate area of El Mirage Lake.
Antelope Valley 6-44			X	X	Water quality is generally suitable for most uses. Extensive withdrawals of ground water are being made for urban and agricultural uses.
Tehachapi Valley 6-45	X		X		The basin is small (20 mi^2); consequently, storage is limited. Water quality is generally suitable for most uses.
Fremont Valley 6-46			X	X	Water quality is generally suitable for most uses, except in the immediate area of Koehn Lake where water extremely high in dissolved solids is being used for the production of salt.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin: Storage	Well yield	Water quality	Basin development	Explanation
Goldstone Valley 6-48	X			X	The basin is small (30 mi^2); consequently, storage is limited. Most of the basin is within a U.S. military reservation.
Superior Valley 6-49		X		X	Well yields are low; the alluvium has a maximum thickness of 250 ft (Moyle, 1971), which limits well yield. Nearly half the basin is within a U.S. military reservation.
Cuddeback Valley 6-50			X		Water quality is generally suitable for most uses, except in the areas immediately north and northwest of Cuddeback Lake.
Pilot Knob Valley 6-51				X	The basin is within a U.S. military reservation.
Searles Valley 6-52			X	X	Most of the ground water in the basin has an extremely high dissolved solids concentration. This water is processed into salt, a major industry in the basin.
Salt Wells Valley 6-53	X			X	The basin is small (30 mi^2); consequently, storage is limited. Most of the basin is within a U.S. military reservation.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin: Storage	Well yield	Water quality	Basin development	Explanation
Indian Wells Valley 6-54				X	There is moderate urban and industrial development in the southern part of the basin. The northern half the basin is within a U.S. military reservation.
Coso Valley 6-55				X	The basin is within a U.S. military reservation.
Rose Valley 6-56	X		X		The basin is small (60 mi^2); consequently, storage is limited. The water quality in most of the basin is suitable for most uses.
Darwin Valley 6-57				X	Most of the basin is within a U.S. military reservation.
Basins 6-59 through 6-90	X				These basins are all small and have insignificant amounts of ground water in storage.
Lanfair Valley (7-1)	X	X	X		The water table is deep; therefore, storage in the upper 500 ft of sediments is limited. Well yields are generally less than 35 gal/min. Water quality is generally suitable for domestic and agricultural uses.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin				Explanation
	Storage	Well yield	Water quality	Basin development	
Fenner Valley 7-2		X	X		Existing wells have yields below 200 gal/min. Water quality is generally suitable for domestic and agricultural uses.
Pinto Valley 7-6	X			X	Depth of water-bearing sediment is only 100 ft. The basin is within the Joshua Tree National Monument.
Cadiz Valley 7-7		X	X		Only low yields are available from the tightly compacted clay and silt associated with the large playa. Water is highly saline; dissolved solids are greater than 200,00 mg/L.
Bristol Valley 7-8		X	X		Low yields are due to fine, compacted sediments. Water is highly saline; dissolved solids are greater than 200,000 mg/L.
Twentynine Palms Valley 7-10			X	X	Water quality is generally suitable for domestic and agricultural uses in most parts of the basin. Basin is within a U.S. military reservation.
Copper Mountain Valley 7-11			X	X	Water quality is generally suitable for domestic and agricultural uses.
Warren Valley 7-12	X				The basin is small (20 mi^2); consequently, storage is limited.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin				Explanation
	Storage	Well yield	Water quality	Basin development	
Deadman Valley 7-13				X	The basin is within a U.S. military reservation.
Lavic Valley 7-14	X	X			The basin is small (40 mi^2); consequently, storage is limited. Maximum reported well yield is 140 gal/min.
Bessemer Valley 7-15				X	The basin is partly within a U.S. military reservation.
Ames Valley 7-16				X	The basin is within a U.S. military reservation.
Means Valley 7-17	X		X		The basin is small (25 mi^2); consequently, storage is limited. The water quality is suitable for domestic and agricultural uses.
Johnson Valley 7-18			X	X	Water is marginal for domestic use. High fluoride levels require mixing of the water. 150 to 300 private parties use well water.
Lucerne Valley 7-19			X	X	Water quality is generally suitable for domestic and agricultural uses. There is moderate development in the basin.
Morongo Valley 7-20	X				The basin is small (14 mi^2); consequently, storage is limited.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin				Explanation
	Storage	Well yield	Water quality	Basin development	
Coachella Valley 7-21				X	The basin is used extensively for both domestic and agricultural purposes. An overdraft already exists.
Clark Valley 7-23	X	X			The basin is small (40 mi^2); consequently, storage is limited. Well yields average 20 gal/min.
Borrego Valley 7-24			X	X	The water is suitable for domestic and agricultural uses. Part of the basin is within the Anza Borrego State Park.
Ocotillo/ Lower Borrego Valley 7-25			X	X	The water is generally suitable for domestic and agricultural uses.
Terwilliger Valley 7-26	X				The basin is small (12 mi^2); consequently, storage is limited.
San Felipe Valley 7-27	X				The basin is small (40 mi^2); consequently, storage is limited.
Vallecito-Carrizo Valley 7-28				X	The basin is within the boundary of Anza Borrego State Park.
Coyote Wells Valley 7-29			X	X	Water quality is generally suitable for domestic and agricultural uses. Ground water is being exported from basin.
Imperial Valley 7-30			X	X	Extensively developed for domestic and agricultural uses. Geothermal development is increasing.

TABLE 4.--Basins considered unsuitable for powerplants --Continued

Basin name and number	Criteria eliminating basin: Storage	Well yield	Water quality	Basin development	Explanation
Orocopia Valley 7-31		X			Only low yields are available from highly cemented sediments.
Chocolate Valley 7-32				X	About half the basin is within a U.S. military reservation.
East Salton Sea Basin 7-33		X		X	Well yields are limited because the aquifer is thin. Basin has moderate development.
Yuma Valley 7-36		X		X	The thickness of the principal aquifer is only 225 ft. Basin is within the Fort Yuma Indian Reservation.
Palo Verde Valley 7-38			X	X	Water quality is suitable for domestic and agricultural uses; consequently, basin has been extensively developed.
Quien Sabe Point Valley 7-40	X				The basin is small (40 mi^2); consequently, storage is limited.
Needles Valley 7-44			X	X	Water quality is generally suitable for domestic and agricultural uses. Basin has moderate development.
Piute Valley 7-45		X			Depth to water is 265 to 414 ft below land surface. The sediments are tightly cemented at depth.
7-47 through 7-61	X				These basins are too small to meet the storage requirements.

SUMMARY AND CONCLUSIONS

To meet electric-power needs in the future, powerplants may have to be constructed at inland sites and use ground water for cooling purposes. This report describes the results of a reconnaissance to determine which basins are hydrologically suited for powerplant sites in the desert area of southern California.

The hydrologic criteria used in evaluating each of the 142 basins was based on the assumption that any proposed powerplant would use fossil fuel and have a 1,000-megawatt capacity. To ensure an adequate water supply for the planned 30-year life of the powerplant, a minimum of 1 million acre-ft of recoverable water in storage was assumed to be required. A minimum well yield of 500 gal/min was established. At 500 gal/min, 37 wells pumping continuously would produce the required 30,000 acre-ft/yr. Assuming a minimum of 500 gal/min, however, the average well yield would probably be greater because well yields would vary from site to site.

Water-quality criteria were determined on the basis of competitive use; only ground water that is unsuitable for domestic and agricultural uses was considered available for powerplant cooling. Minimum concentrations were set at 1,000 mg/L dissolved solids, 1.5 mg/L fluoride, 50 μg/L arsenic, 2,000 μg/L boron, and a percent sodium of 75. The upper limit for dissolved solids was set at 30,000 mg/L.

The criteria for basin development were established to avoid conflict. Basins that have been extensively developed were eliminated from consideration as powerplant sites. Basins that are largely or totally within a national monument or military reservation were also eliminated from consideration.

The following basins are classified as suitable with respect to the established criteria: Amargosa Valley (6-20); Soda Lake Valley (6-33); Caves Canyon Valley (6-38); Chuckwalla Valley (7-5); and Calzona-Vidal Valley (7-41, 7-42).

The following basins classified as suitable with qualifications seem to meet the established criteria but in some respects the available data are inconclusive: Coyote Lake Valley (6-37); Harper Valley (6-47); Panamint Valley (6-58); Rice Valley (7-4); Dale Valley (7-9); and Palo Verde Mesa (7-39).

The following basins could not be classified, because of insufficient data, but are potentially suitable: Eureka Valley (6-16); Saline Valley (6-17); Lower Kingston Valley (6-21); Upper Kingston Valley (6-22); Riggs Valley (6-23); Kelso Valley (6-31); Broadwell Valley (6-32); Ward Valley (7-3); West Salton Sea (7-22); Amos Valley (7-34); Ogilby Valley (7-35); Arroyo Seco Valley (7-37); and Chemehuevi Valley (7-43).

The remaining basins were eliminated from consideration because they did not meet the established criteria.

The next phase of basin evaluation could involve direct hydrologic investigation and data gathering. The order of priority, for detailed hydrologic evaluation, could be basins classified suitable, basins suitable with qualifications, and basins with insufficient data.

These basins could be investigated by reconnaissance surface-gravity techniques to help determine the depth and subsurface configuration. Additional water-level measurements could be made and water samples collected for chemical analysis. The final phase could include test drilling and pumping tests.

Qualitative estimates can be made of the effects on the basin of intensive groundwater withdrawals. The water level in the entire basin will decline, and pumping depressions will form around each well and around the well field collectively. As the pumping depression expands, water of different quality may be drawn into the well field.

Compaction of the dewatered sediments will probably result in land-surface subsidence. Holding ponds may develop leaks and well casings may bend or become out of plumb because of land subsidence.

Well yields will decline as the water table is drawn down. This is because the well is exposed to less and less of the aquifer as the water level declines, and the aquifer yields less water at depth because the aquifer material is more compacted.

The aforementioned negative effects of sustained pumping should be evaluated quantitatively prior to establishing a powerplant in any basin.

RECOMMENDED FURTHER STUDY

Further study is recommended in order to select the most suitable basin or basins for providing cooling water. Additional data are needed on well yields, depth and subsurface configuration of the basins, aquifer properties, and water quality. Test drilling would be required to adequately determine well yields and aquifer properties. It would not be economically feasible to drill test wells in all the basins in the suitable, suitable with qualifications, and inadequate data categories at this point in the study. Therefore, additional investigative work should be done to determine which basins, within each category, have the most hydrologic potential.

It may be best to conduct additional study in two phases (hereafter referred to as the second and third phases). The second phase could be directed at eliminating some basins on the basis of hydrologic properties and assigning a priority to the remaining basins. Upon completing the second phase it may be desirable to eliminate or categorize the basins with respect to factors other than hydrologic, such as accessibility, site cost, and environment. The third phase could consist of drilling test wells in the basins that have the highest priority hydrologically and otherwise.

Work elements for the second phase could consist of measuring water levels, collecting water samples for chemical analysis, making reconnaissance gravity surveys, selecting test-well sites, and estimating aquifer response to ground-water withdrawals. Water-level measurements could be made in selected wells to help determine direction and gradient of ground-water movement. Water samples could be collected from selected wells and analyzed for fluoride, boron, and dissolved solids. A reconnaissance gravity survey could be made for selected basins to help determine basin depth. The gravity survey would probably consist of one or more traverses with long station spacing in order to keep to a minimum the time involved. Tentative sites for test wells could be selected where additional data are required. A rough estimate of aquifer response to ground-water withdrawals could be made by using estimated values for transmissivity and storage coefficient.

After completing the work elements in phase two some of the basins may be eliminated and the remaining basins in each category could be ranked in order of their potential for providing cooling water.

Phase three would be a detailed study of only those basins that are best hydrologically and in all other respects. The work elements for phase three would include drilling test wells and making a more detailed gravity study for each of the remaining basins. Using these data the basins would be assigned priority for greatest potential. The best location for a well-field site, in each basin, could be suggested and the probable effects of sustained pumping at the site could be summarized.

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